CANADA
DEPARTMENT OF MINES
LOUIS CODERRE, Minister A. P. LOW, Deputy Minister
GEOLOGICAL SURVEY
R. W. BROCK, Director

GUIDE BOOK No. 1

EXCURSION
in
Eastern Quebec
and the
Maritime Provinces

PART II

OTTAWA
GOVERNMENT PRINTING BUREAU
1913

GUIDE BOOK No. 1

EXCURSION

IN

Eastern Quebec and the Maritime Provinces

(EXCURSION A 1.)

PART II

ISSUED BY THE GEOLOGICAL SURVEY

OTTAWA
GOVERNMENT PRINTING BUREAU
1913

35063—1A

CONTENTS.

Part II.

ILLUSTRATIONS TO PART II.

MAPS.

PHOTOGRAPHS.

THE RIVERSDALE–UNION GROUP AT TRURO AND IN THE TYPE SECTION ALONG THE INTERCOLONIAL RAILWAY EAST OF TRURO.*

INTRODUCTION.

(G. A. Young.)

The interest attached to the Riversdale–Union series does not lie directly in the structures presented by these measures nor in the characters of the faunas or floras they may carry. It arises from the fact that though this series locally at least, is as much as 10,000 feet (3,050 m.) thick, apparently is widely displayed over a considerable portion of Nova Scotia, and has been studied and mapped in detail, yet one group of geologists holds that the strata are of Devonian age while another group contends that the measures are of Carboniferous, probably Pennsylvanian, age.

The strata of the Riversdale-Union series as exposed along the Intercolonial railway eastward from Truro, occur in a band of so-called Devonian rocks which stretches continuously from Cape Breton island on the east to near Truro on the west where the band forks. One branch continues in a westerly direction along the south side of Minas basin to Horton Bluff near Windsor, the other band parallels the north shore of Minas basin and with some interruptions, extends nearly to Cape Chignecto. The length of the band from Cape Breton to Horton Bluff is about 180 miles (290 km.), in places it expands to a width of nearly 20 miles (30 km.), in other places it contracts to a breadth of only 2 or 3 miles (3–5 km.).

Throughout their whole extent, the measures have been studied by the late Hugh Fletcher and mapped by him in detail on a scale of 1 mile to 1 inch. His work shows that along the borders of the long band of these measures, the so-called Devonian is brought into contact with representatives of most of the geological divisions developed in Nova Scotia, though for many miles at a time the strata are bounded by Carboniferous beds of Mississippian age. The accompanying diagram map prepared from maps of Fletcher exhibits his conception of the geological relations

*See Map—Union-Riversdale.

of a portion of the Riversdale-Union area in a region from which considerable palæontological evidence is forthcoming to indicate that the strata are not of Devonian age but are approximately the equivalents of the Millstone Grit and therefore of Upper Carboniferous or Pennsylvanian age.

For various reasons Fletcher in working out structural details made little or no use of fossils but instead depended solely on stratigraphical methods, and in making correlations was guided almost entirely by structural and lithological characters. Furthermore, during the course of his long life work, as he extended his mapping from the extremity of Cape Breton on the east to and over the Carboniferous areas of the mainland, his views regarding the classification of the Carboniferous changed, but yet, in deference to established custom or for other reasons, the classification as expressed on his maps remained essentially unchanged. As an instance in point, it may be noted that under the term Carboniferous Conglomerate was classed on earlier maps a thick series of coarse sediments supposed to mark the base of the Carboniferous system; on later maps, the term was made to include also a series of shales, etc., recognized as representing the Horton series; while on still later maps, the older meaning of the term Carboniferous Conglomerate was readopted and the Horton beds were mapped as Devonian. Besides the difficulty of interpreting Fletcher's maps arising from the conditions outlined above, a student is confronted with another difficulty due to the fact that if not personally acquainted with the field he is not in a position to understand why, for instance, the area of rocks indicated on the accompanying map as lying north of Riversdale and wholly enclosed by 'Devonian', was classed as Carboniferous Conglomerate, i.e. as the basal portion of the Carboniferous, and not as some higher member of the system. The explanation seems to be that Fletcher from his studies of such sections of the Carboniferous as are exposed at Sydney and Joggins, became convinced that the Carboniferous system where most fully developed, consists in ascending order of Conglomerate series, Limestone series, Millstone Grit, and Productive Coal Measures, and furthermore that the Conglomerate series was more or less local in its development and that in many places the Limestone series forms the base of the Carboniferous.

From the above view points, Fletcher made use of five main arguments to show that the Riversdale-Union and associated strata are of Devonian and not Carboniferous age as held by various palæontologists. It should be remembered that of the contending parties, Fletcher is virtually the only member who has studied the stratigraphy of the region. Fletcher held that the strata in question are of Devonian age because: (1) The measures as compared with the Carboniferous beds, are in general metamorphosed, contorted, and associated with igneous rocks generally absent from the Carboniferous areas. (2) The measures contain fossil plants, etc., of Devonian types. (3) The measures closely resemble the Little River group of St. John, N.B., which by Dawson was placed in the Devonian. (4) The measures cannot lie above the Limestone series since they are not developed in such well defined sections as those of Joggins and Sydney harbour. (5) The measures lie unconformably beneath the Carboniferous Limestone series.

As opposed to the above arguments it may be urged: (1) That, deductions based on relative degrees of metamorphism and of disturbance of the strata and on the presence or absence of igneous bodies, are not always reliable since by using such arguments, Fletcher [**5**] in the case of one area, grouped in the Devonian certain metamorphosed, disturbed, fossiliferous limestones and associated beds cut by igneous rocks but later [**6**, p. 33 and pp. 44-45; **7**], in spite of their evident metamorphism and disturbed condition, placed them with the Carboniferous and stated [**6,** p. 54] that some of the Carboniferous strata are as much altered as the so-called Devonian. (2) That, though the assemblage of varied measures grouped by Fletcher as Devonian do hold Devonian fossils in places yet this is only so because the so-called Devonian is made up of diverse elements including the fossiliferous lower Devonian of Arisaig. But the bulk of the strata, so far as the fossiliferous evidence goes, is held by palæontologists to be of Carboniferous age and to include measures representative of the Horton series at the base of the system and of horizons about equivalent to the Millstone Grit in the upper part of the system. (3) That, the bulk of the so-called Devonian may represent the Little River group of St. John, N.B., is generally conceded but though Dawson assigned the Little River group on palæontological evidence to the

Devonian, yet most palæontologists now agree that the age of the Little River group is approximately that of the Millstone Grit. Furthermore it does not appear that the stratigraphical evidence of the Devonian age of the Little River group is any more definitely proven than in the case of the Riversdale-Union series. (4) The argument that the Riversdale-Union series cannot be younger than and therefore overlie the Limestone series because of its absence from such a position in such relatively clearly developed sections as the Joggins and at Sydney, is, in part at least, met by the results of recent work by Hyde in the Sydney basin (see later pages). (5) The main argument as put forward by Fletcher, that the Riversdale-Union is unconformably overlain by the Limestone series, remains to be considered. Those who disagree with Fletcher's conclusions are forced to adopt one or more of the three following explanations. (*a*) That, Fletcher has placed together under the heading of Devonian, different groups of strata of diverse ages and that where the Limestone series unmistakably overlies 'Devonian' strata, the older measures are not the equivalent of the Riversdale-Union series. That in some instances such may be the case, is demonstrated in the instance of the Horton series near Windsor and of the lower Devonian of Arisaig both of which groups almost of a certainty unconformably underlie the Carboniferous Limestone series but are not the equivalents of the Riversdale-Union series. (*b*) That, where the Riversdale-Union is unmistakably overlain by strata of Carboniferous age, Fletcher was mistaken in correlating the overlying measures with either the Carboniferous Conglomerate or the Carboniferous Limestone. Except possibly in one instance, no independent attempt has yet been made to prove this contention. (c) That, where Riversdale- Union and members of the Mississippian are in contact, Fletcher was mistaken in regard to his interpretation of the structures. In this connection it is justifiable to point out, that though Fletcher was emphatic in his oft repeated declaration of the unconformable superposition of the Limestone series upon the Riversdale-Union, yet in no instance did he present detailed statements of the evidence of such a relation but mainly was content to assert that at various points one division unmistakably overlay the other. That mistakes of interpretation may have arisen is not an unwarranted supposition in view of the fact that the geolo-

gical structure of the region in general is admittedly intricate, and exposures at critical points are usually imperfect.

In view of the above stated lines of criticism it must be emphasized that, whatever results future study of the facts in the field may yield, in the opinion of all who have used Fletcher's maps, the boundaries laid down on them by him will be found to accurately indicate the limits of structural or stratigraphical units even though, eventually, it may be proven that errors of classification and correlation exist.

Of the geologists who have held opinions contrary to those advocated by Fletcher, nearly all have based their arguments solely on palæontological grounds. Dawson from the first held that the strata in question are of Carboniferous age and so described and mapped them in the first edition of Acadian Geology published in 1858. The following fossils have been determined by Dawson [**4**; **3**, p. 29] as occurring in the strata of the type section along the Intercolonial railway. Possibly the list as given is incomplete, since Dawson did not always record localities from which fossils were obtained.

Anthracomya (Naiadites) elongata.
A. lævis.
Calamites cistii.
C. cannæformis.
Lepidophloios acadianus.
Odontopteris antiqua.
Cardiopteris,—
Pectopteris abbreviata.
Hymenophyllites furcatus.

From the character of the fossils, Dawson considered the containing strata to be of Millstone Grit age.

In 1897 and succeeding years, H. M. Ami visited many localities within the so-called Devonian area and made extensive collections of fossils. Representative collections were sent to Robert Kidston, David White, T. Rupert Jones and Henry Woodward, all of whom as pointed out Ami [**1**; **2**] and Whiteaves [**9**], united in agreeing that the fossils indicated that the strata are of Carboniferous age while Kidston and White agreed that the horizon was well up in the Carboniferous. White [**8**] in a later paper has directly presented his conclusions and has shown that Kidston and he are in essential agreement in placing the horizon of the strata at or about that of the Millstone Grit.

Ami in one of his papers [**2**, pp. 168-9], has assembled the determinations of the various palæontologists and the

following list of fossils collected from the type section of the Riversdale series along the line of the Intercolonial railway is the result. The plants were determined by Kidston, the entomostraca by T. Rupert Jones, and the crustacea by Henry Woodward.

Asterophyllites acicularis.
Sphenopteris marginata.
Neuropteris sp.
Alethopteris sp. allied to A. valida.
Cordaites principalis.
C. robbii.
Cyclopteris (Nephropteris) varia.
Calamites sp.
Cardiocarpum cornutum.
Belinurus grandævus.
Leaia tricarinata.
Leaia leidyi var. baentschiana.
Anthracomya elongata.
A. obtusa.
Spirorbis eriaia.
'A neutopteroid insect allied to Miamia bronsoni' determined by Charles Brongniart.

BIBLIOGRAPHY.

1. Ami, H. M.....Geol. Surv. Can., Summary Report for 1899, pp. 201-204.

2. Ami, H. M.....Proceedings and Transactions, Nova Scotian Institute of Science, vol. XI, pp. 162-178, 1903.

3. Dawson, W. J.....Geol. Surv. Can., Report on the fossil plants of the Lower Carboniferous and Millstone Grit formations of Canada, 1873.

4. Dawson, W. J.....Geol. Surv. Can., Annual Report, vol. II, p. 64 P, 1886.

5. Fletcher, Hugh....Geol. Surv. Can., Report of Progress, 1877-78, p. 18 F.

6. Fletcher, Hugh....Geol. Surv. Can., Report of Progress, 1879-80, part F.

7. Fletcher, Hugh....Geol. Surv. Can., Annual Report, vol. II, p. 50 P. 1886.

8. White, David.....Can. Record of Science, vol. III, pp. 270-280, 1910.

9. Whiteaves, J. F....Amer. Geol. vol. XXIV, pp. 210-40, 1899.

CHARACTER AND FAUNA OF THE RIVERSDALE AND UNION FORMATIONS.

(J. E. Hyde.)

The Riversdale and Union formations are each very thick. The combined thickness has been estimated to be 10,000 feet (3,050 m.) and this is probably not exaggerated. The Riversdale, which is the older, is composed of grey, red and purplish shales, with sandstone beds. It differs from the Union in the greater proportion of grey shales, the Union being almost without exception bright red in colour. There is, however, a considerable thickness of red shale in certain portions of the Riversdale.

The strata are evenly bedded and are clearly water laid. Only occasionally are there evidences of strong current action. Mud-cracked beds are not infrequent and the sandstones are composed frequently of undecomposed rocks and mineral fragments. Rarely does a thin bed of coal occur in the Riversdale.

The fauna and flora which have been described from the "Riversdale-Union" series appear to have been collected largely from the upper part of the Riversdale, but the exact localities and horizons have not been specified. Although the Union formation is almost barren, the writer has obtained the same fauna with *Leaia* and *Anthracomya* in beds almost at the top of the Union at Union station, where plant remains also occur. Both the fauna and flora are abundantly preserved in numbers of individuals if not in species, in the upper beds of the Riversdale at railroad cuts a short distance east of Riversdale station. Eastward from these cuts these remains are observed less often. Here and at every point where they have been found by the writer, the faunas are confined almost entirely to the beds of grey shale. Very rarely indeed are remains found in the red shales. The Leaia is most commonly found in beds of slaty, almost black shale. This same mode of occurrence obtains in the Point Edward formation at Sydney, believed to be an approximate equivalent of the Riversdale and Union, or of some portion of them.

ANNOTATED GUIDE.

Truro to Campbell's siding.

(J. E. Hyde.)

Miles and Kilometres.

0 m.
0 km. **Truro**— Alt. 60 ft. (18 m.). Truro is situated on the south bank of the westward flowing Salmon river which, a few miles to the westward, empties into the Bay of Minas. For 6 miles (9·6 km.) above Truro, the Salmon river flows through a tract underlain by Triassic measures consisting of red conglomerates, sandstones and shales. To the westward of Truro, similar Triassic strata fringe both sides of the Bay of Minas and continue uninterruptedly along the Cornwallis-Annapolis valley to beyond Digby 135 miles (217 km.) west of Truro. Along the north side of the Cornwallis-Annapolis valley the Triassic sediments are overlain by a thick series of flows of amygdaloidal and basaltic diabase. The Triassic measures are usually horizontal or possess low angles of dip, but locally, the measures are faulted and otherwise disturbed.

At Truro the southern boundary of the Triassic with the measures of the Riversdale-Union group lies ¼ mile (0·4 km.) south of the railway. In Victoria Park which lies just south of the station, the rocks of the Union formation are excellently shown in the walls of a stream gorge of unusual scenic beauty. The stream which is of considerable size, appears to have been deflected from its course by the Pleistocene glaciers and it has cut a short, rugged gorge into the head of which it falls in a series of cascades. The Triassic sandstones are also exposed in the park, lying on the upturned Union beds, but the contact is not clearly shown.

Leaving Truro, the Intercolonial railway proceeds in an easterly direction up the flat wide valley of Salmon river. On the north bank of the river, visible from the railway, are cut banks in red, Triassic sandstone.

Miles and Kilometres.

4·7 m. 7·6 km. **Valley Station**—Alt. 102 ft. (31 m.). Beyond Valley station, rock cuttings in the red Triassic occur along the railway and continue on the north bank of the river. After passing Valley station the river valley narrows.

6·7 m. 10·8 km. **Salmon Siding**—Salmon Siding is close to the eastern end of the Triassic basin. At this point, the contact of the Triassic with the Union formation is excellently shown on the north bank of Salmon river. The steeply dipping Union measures are truncated by a nearly horizontal plane and on them repose the flat-lying Triassic sandstones.

For a distance of about 4½ miles (7·2 km.) east from Salmon Siding, the railway follows the valley of Salmon river; beyond this point it follows up the valley of Black river, a tributary of Salmon river. From near Salmon Siding eastward to beyond Riversdale these streams are bordered by simple rock and drift terraces. The stream flows in a narrow gorge less than 100 feet (30 m.) deep below Union, which becomes shallower up stream. The rock terraces bordering this gorge are capped by 40 to 50 feet (9 to 15 m.) of drift, apparently stream laid gravels. The larger tributaries to the major streams show similar conditions.

The gravel terraces appear to belong to the closing stages of the Pleistocene. Back of Riversdale station and only 200 or 300 metres from the railroad, there is preserved on this old high-level, gravel floor, a sharply defined abandoned stream channel. It runs from the edge of Calvary river gorge westward behind the village for a distance of only a few hundred metres where it passes into a short gully which descends to Black river at Riversdale station. It is clearly the old channel of Calvary river at the time when all the streams flowed on the old high-level gravel floor, but abandoned for the present nearby outlet probably before they had cut through the gravels and into the hard rock.

Miles and Kilometres.

The channel is sharp, and indicates abandonment at a very recent period.

The relation of drift cap to rock wall can be seen fairly well in the contours of the valley walls, and both are laid bare by the cutting of Black river just opposite Riversdale station.

Apparently the rock gorge has been cut entirely subsequent to the accumulation of the gravels. No evidence has been seen of an older set of channels cut prior to the gravel stage and covered by the gravels, to be later uncovered to form in part the present gorge.

From the edge of the Triassic area at Salmon Siding, eastward almost to Union station, a distance of about 2 miles (3·2 km.), the dominantly red beds of the Union formation are shown, almost continuously, in numerous long rock cuttings, with an easterly dip of about 25°.

9 m.
14·5 km.

Union Station—Alt. 218 ft. (66·4 m.). In the rock cuttings west of Union station, the beds are on the western limb of a syncline, the highest beds of which are located just west of Union. Eastward from Union, the direction of dip is reversed, and lower and lower beds are exposed until the passage into the underlying Riversdale is reached a short distance west of Riversdale station. The contact between the Riversdale and Union is not a sharp one, and it is nor clear why Fletcher drew it at this point. It appears, however, that the boundary must be arbitrarily chosen.

12·7 m.
20·4 km.

Riversdale Station—Alt. 314 ft. (95·7 m.). West of Riversdale station, the rock cuttings are in the grey rocks of the Riversdale formation. In the rock cuttings about ½ mile (0·8 km.) east of Riversdale, fossils occur. In one cutting, the fauna, large in individuals but few in species, is found in beds of grey and black shale; at this locality, *Leaia* and *Anthrocomya* occur. In a rock cutting beyond this point, plant fragments occur abundantly in a sandy shale.

Beyond the rock cuttings west of Riversdale

Miles and Kilometres.

the valley of Black river entirely loses its deep-set character and the exposures of the Riversdale formation become more and more infrequent.

16·5 m. 26·5 km. **Campbell's Siding**—Alt. 429 ft. (103·7 m.). A short distance east of Campbell's Siding, the barren beds of the Riversdale formation are well displayed in a number of cuttings.

ANNOTATED GUIDE.

Campbell's siding to New Glasgow.

(G. A. Young.)

Eastward from Campbell's Siding the railway follows upwards along the shallow valley of Black river. The grey shales and sandstones with red zones, of the Riversdale formation are exposed in numerous rock cuttings. The strata dip at high angles to the northwest and therefore, proceeding easterly, are crossed in descendding order. Two and three-quarter miles (4·4 km.) east from Campbell's Siding, the railway crosses a low divide, (altitude 505 ft. or 153·9 m.) and enters a watershed draining to the northeast to the Gulf of St. Lawrence.

20.7 m. 33·3 km. **West River Station**—Alt. 441 ft. (134·4 m.). About 1½ miles (2·4 km.) east of West River station, the railway crosses the boundary between the Riversdale and Union formations. Few, if any, rock exposures occur along the railway.

30·1 m. 48·4 km. **Lorne Siding**—Alt. 365 ft. (111·2 m.). From near West River to beyond Lorne Siding, the railway follows close to the boundary between the Riversdale and Union formations. In this general district the sedimentary strata are associated with numerous relatively small bodies of igneous rocks whose origin and composition is unknown.

Beyond Lorne Siding the railway enters the valley of Cameron brook and at a point about 1½ miles (2·46 km.) farther enters an area of the

Miles and Kilometres.

Carboniferous Limestone series. The Riversdale strata are separated from those of the Carboniferous Limestone series by a fault, but from evidence obtained elsewhere, Fletcher was convinced that the Carboniferous Limestone series overlaid the Union-Riversdale group. The reddish shales and sandstones of the Carboniferous Limestone series are exposed in rock cuttings along the railway and in the valley of Cameron brook. The strata are much disturbed and in places are vertical. The strata of the Carboniferous Limestone series occupy a large area forming the southern boundary of the Pictou coal field. The measures are largely reddish shales and sandstone with many beds of limestone and argillaceous limestone. Logan, Dawson, Fletcher and other geologists have all agreed in calling the strata the Carboniferous Limestone series with the implication that the measures at least roughly correspond in age with the Windsor series.

35 m. 56·3 km. **Hopewell Station**—Alt. 206 ft. (62·8 m.). Before reaching Hopewell, the railway turns to the north and proceeds down a large branch of the West river of Pictou. The red strata of the Carboniferous Limestone series are exposed along the railway and on the banks of the stream, dipping in various directions, commonly at rather low angles. Approaching Eureka, the stream valley first becomes gorge-like and then broad and deep.

36·5 m 58·7 km. **Eureka Station**—Alt. 145 ft. (44·2 m.). At Eureka the railway enters the deep-set valley of the East river of Pictou. This river for 12 miles (19·3 km.) above Eureka station flows through a district underlain by strata of the Carboniferous Limestone series but towards the southeast, for a distance of about 5 miles (8·0 km.) along the railway, these measures occur only in the valley bottom and form a band nowhere more than ½ mile (0·8 km.) wide. On the south, the Limestone series is bounded by an area of the Union-Riversdale series; on the east they abut against a rough,

Miles and Kilometres.

hill country occupied by Silurian and Ordovician strata associated with large and small bodies of igneous rocks varying in character from granites to fine-grained acid and basic volcanics. Associated with the Silurian and other strata are deposits of spathic and hematitic iron ore. These deposits have been mined and at one time were smelted in furnaces at Eureka which are visible from the railway.

37·3 m. 60·0 km. **Ferrona Junction**—Alt. 129 ft. (39·3 m.). The reddish strata of the Carboniferous Limestone series are exposed along the river for about 1 mile (1·6 km.) below Ferrona Junction, where for a short distance they are replaced by hard, reddish sandstones and slates thought to belong to an underlying series of Devonian age. These measures form a ridge rising to a considerable height on the east side of the river. The 'Devonian' strata are bounded by east-west faults and on the north side, the Devonian Limestone series is repeated.

After passing the narrow band of 'Devonian' the country lowers and becomes broadly rolling in character. Before reaching Stellarton, the railway leaves the Carboniferous Limestone area, crosses a mile-wide strip of Millstone Grit and enters a district occupied by Coal Measures.

40·8 m. 65·6 km. **Stellarton**—Alt. 58 ft. (7·7 m.). Stellarton is one of the mining centres of the Pictou bituminous coal field. The Coal Measures in this field occupy an irregular oval-shaped area, 10½ miles (16·9 km.) long in an east and west direction and, at the widest point, about 3 miles (4·8 km.) broad. The total area of the Coal Measures is in the neighbourhood of 20 square miles (50 sq. km.). The irregular oval or lozenge outline of the area is marred towards the centre of the field by a tongue-like area of Millstone Grit projecting from the southern boundary along an anticlinal axis. Except at the western end of the field and in the neighbourhood of the above mentioned tongue-like projection of Millstone Grit, the area of the Coal Measures is bounded by a system of faults whereby the

Miles and Kilometres.

Coal Measures along the southern boundary are brought into contact with strata of the Limestone series, while along the eastern and northeastern boundary they are brought into contact with the Millstone Grit, and along the northwestern boundary into contact with the New Glasgow Conglomerate supposed by Fletcher to be of Permian age. The fault system is a complex one and comparatively little has been recorded of the magnitude and nature of the individual faults. In general there appears to be a set of major faults striking in an east and west direction; another set in a northeasterly direction and a third set in a northwesterly direction. The Coal Measures are also traversed by faults and one of these striking in a northwesterly direction, dipping to the northeast, and causing a downthrow of the strata on the southwest side of approximately 2,600 ft. (790 m.), divides the field into two main districts, respectively the western and eastern districts. In the western district, the strata dip in general to the northeast at angles varying from 15° to 50°. In the larger, eastern district, the strata in the eastern part are traversed by a north-south syncline while in the western part the main feature is a northeasterly pitching anticline. The major structural features of the two areas are complicated by the presence of minor undulations extending in an east-west as well as other directions, and of many faults of varying relative importance.

In the eastern district, which includes the district immediately around Stellarton, the coal seams occur in two sets, an upper and a lower, separated by about 1,600 feet (485 m.) of barren rock, mostly dark shale. The upper set of coal seams is exposed in the eastern part of the area, and the lower set in the western part in the neighbourhood of Stellarton. In the upper set there are five main seams of coal varying in thickness from 3 feet to 8 feet (0·9 m. to 2·4 m.). In the lower set there are six main coal seams. One seam, known

Miles and Kilometres.

as the Main seam, varies in thickness as traced along the outcrop or in depth, from less than 7 feet (2·1 m.) to 45 feet (13·7 m.). Another seam ranges in thickness from 20 feet (6 m.) to 33·5 feet (10 m.). A third seam, the lowest, varies in thickness from 11 feet to 19 feet (3·3 m. to 5·8 m.).

In the western of the two main areas, there are four main coal seams supposed to be the equivalents of seams of the lower set occurring in the Stellarton district. As in the eastern district the individual seams vary widely in thickness from place to place. The largest seam varies in this respect from less than 4 feet to 18 feet (1·2 m. to 5·4 m.).

From Stellarton the railway continues for about $1\frac{1}{2}$ miles (2·4 km.) along the west side of the East river of Pictou, then crosses the river and enters the town of New Glasgow. A very short distance beyond the station, the railway crosses the course of an east-west fault limiting the area of the Coal Measures in that direction.

42·9 m.
69 km.

New Glasgow—Alt. 29 ft. (5·8 m.).

THE NEW GLASGOW CONGLOMERATE.*

(G. A. Young.)

INTRODUCTION.

Along the banks of the East river, in the vicinity of New Glasgow, are exposures of a red, coarse conglomerate which has received the name, New Glasgow Conglomerate. This formation is the basal member of a very thick group of strata which in a comparatively undisturbed condition, floor the country north and west of New Glasgow, outcropping along the Nova Scotian and New Brunswick shores of Northumberland strait for a distance of about 80 miles (130 km.), and underlying the whole of Prince Edward Island. What have been described as equivalent

* See Map,—New Glasgow.

measures also occur in the western part of the Joggins section along the Bay of Fundy coast. The distribution of this group of strata is confined, so far as known, to the general region lying north of the Cobequid Hills which stretch easterly from the Bay of Fundy to not far from New Glsagow, a distance of about 100 miles (160 km.). In the portion of Nova Scotia north of the Cobequid Hills and the adjacent portion of New Brunswick, and in Prince Edward Island, this thick group of strata of which the New Glasgow Conglomerate in places forms the base, occurs in four distinct basins or areas. One, the Prince Edward Island area, occupies the whole of that island and is separated by the waters of Northumberland strait from a second which lies on the mainland fronting Prince Edward Island. The second area stretches westerly to the head of the Bay of Fundy, lies partly in New Brunswick, partly in Nova Scotia. It is separated from the two remaining areas by an anticlinal axis of folding running eastward from the head of the Bay of Fundy to Northumberland strait and along which are exposed Carboniferous strata of the age of the Productive Coal Measures and older. The third area fronts on the Bay of Fundy coast, forms the western portion of the famous Joggins section, and extends inland along the north flank of the Cobequid Hills. It is separated from the fourth area by axes of folding along which are exposed older Carboniferous rocks. The fourth area may be named the New Glasgow area. It stretches from New Glasgow westward along the north flank of the Cobequids and northward from the foot of the hills to Northumberland strait.

This widely extended and thick group of strata of which in certain districts, the New Glasgow Conglomerate forms the natural base, appears everywhere to form a conformable series and in places, even appears conformable with the Productive Coal Measures. The strata are largely sandstones and because, in certain districts, varieties of a red colour predominate, the earliest geological observers assigned the group in general, to the Triassic. As geological investigations progressed, the term Triassic was applied only to the supposedly higher members of the group as displayed in Prince Edward Island. Later the application of the term Triassic was restricted to a small portion of the highest beds on Prince Edward Island in which had been found reptilian remains of a supposedly

Triassic genus. Still later, it was determined that the reptilian remains had been misidentified and that they represented a lower Permian genus; consequently the highest beds on Prince Edward Island are definitely considered to be of Permian age.

During the flux of time as opinions changed regarding the age of the highest members of this great group of strata, various terms were applied to the lower divisions by Sir W. J. Dawson and other observers, These terms were such as Newer Coal formation [**1**], Upper Coal formation [**2**], Permo-Carboniferous [**4**], Permian, etc. In all cases the different terms were used with the definitely stated or plainly implied meaning that the group of strata represented a thick series laid down uninterruptedly from late Carboniferous on into Permian time. In certain districts as for instance where the strata are exposed along the Joggins shore, there is no appearance in the exposed sections of an unconformity between the Carboniferous Coal Measures and the overlying Permo-Carboniferous group. In other districts, as in the neighbourhood of New Glasgow, the evidence implies the existence of a profound stratigraphical break above what is customarily considered to be the horizon of the Productive Coal Measures but below the summit of the Carboniferous. Presumably, sedimentation ceased over the greater part if not over the whole region in later Carboniferous time, and in places at least, the strata were folded, faulted and eroded. In other places the strata were scarcely deformed at all, perhaps but little eroded and, it is possible that in some local areas the processes of sedimentation may have operated continuously. At a later date but still before the close of Carboniferous time, the processes of sedimentation were renewed and continued in force during the closing epochs of Carboniferous and the opening period of Permian time.

The conclusion that the strata of the above mentioned four areas are all portions of one great, unbroken group, rests on evidence collected by Dawson and afterwards substantiated by the detailed field studies prosecuted by Fletcher. There does not seem to be any reasonable grounds for doubting the truth of this general conclusion. It is, however, as yet uncertain how high the strata range in the four main areas though it has generally been thought

that the highest strata are present only on Prince Edward Island. In the New Glasgow area the total thickness of the strata is very great. In the case of one section, a detailed estimate by Fletcher [**8**, p. 114] gives a thickness of above 8,000 feet (2,440 m.) chiefly sandstones, and shales, overlying a basal series of conglomerates, etc., of undetermined thickness but presumably not less than 1,000 feet (300 m.). In the case of a second section [**8**, p. 117] measured a few miles to the west of the first, the thickness including the conglomerate strata at the base, amounts to slightly over 5,000 feet (1,520 m.). The difference in the total estimated thickness of the two adjoining sections is in part accounted for by the presence of a fault in the case of the section with the smaller total. However, having regard to the character of the strata, it is reasonable to suppose that the total thickness may vary rapidly from place to place. In view of what has been stated it may be concluded that the total thickness of the whole group is not less than 10,000 feet (3,000 m.).

The age of the group in general, depends upon the finding of reptilian remains in what are supposed to be the highest strata of the group on Prince Edward Island; and on the palæobotanical studies of Dawson. The facts of the case in connection with the reptilian remains have been summed up by Lambe [**10**] as follows:—The fossil remains found, consist of a "portion of the head of the Rhynchocephalian reptile (which was) described in 1854 by Leidy as the mandibular ramus of a Triassic dinosaur under the name *Bathygnathus borealis*. In 1876,....., Sir Richard Owen drew attention to the fact that the specimen appertained in reality to the upper jaw and referred it to the Theriodontia. Later in 1905, v. Huene and Case independently recognized its true position in the Pelycosauria but its exact generic affinities are still in doubt..... The Pelycosauria are typical of the Permian."

The following tabulation of the plants recovered from the Permo-Carboniferous is based on one prepared by Dawson [**4**] with the addition of a few species which Dawson believed came from Triassic measures on Prince Edward Island [**3**].

	Nova Scotia.		Prince Edward Island.	
	Lower Part.	Upper Part.	Lower Part.	Upper. Part.
Dadoxylon (Araucaroxylon) edvardianum				x
Cycadoidea (Mautellia) abequidensis				x
Dadoxylon materiarium	x	x	x	
Walchia (Araucarites) gracilis		x	x	
W. robusta			x	
Sigillaria scutellata	x			
Calamites suckovii	x	x	x	
C. cistii	x	x	x	
C. gigas			x	
Calamodendron approximatum	x			
Annularia sphenophylloides	x	x		
A. longifolia	x	x		
Sphenophyllum emarginatum	x			
S. longifolium	x			
Cyclopteris heterophylla	x			
C. fimbriata	x			
Neuropteris flexuosa	x	x		
N. cordata	x	x		
N. heterophylla	x			
N. rarinervis	x	x	x	
N. auriculata	x	x		
Odontopteris schlotheimii	x			
Sphenopteris latior	x			
Alethopteris nervosa	x	x	x	
A. serlii	x			
A. acuta	x			
Pecopteris arborescens	x	x	x	
P. abbreviata	x			
P. unita	x			
P. rigida		x	x	
P. oreopteroides	x	x	x	
Beinertia goepperti	x			
Palaeopteris acadica	x			
Cordaites simplex	x	x	x	
Lepidodendron pictoense	x	x		
L. undulatum	x			
Lepidophloios parvus	x			
Trigonocarpum noeggerathii	x			
Rhabdocarpus insignis	x			
Antholithes squamosus	x			

Though by all geologists it has been conceded that the New Glasgow Conglomerate at New Glasgow, is the base of a continuous series of sediments whose upper portion is of Permian age, yet there are two views advocated regarding the age of the New Glasgow Conglomerate itself. By Dawson and Hartley it has been contended that the conglomerate is of Millstone Grit or early Productive Coal Measures age; this view was accepted by Logan. On the other hand, Poole and Fletcher have argued that the conglomerate is of post-Productive Coal Measures age. Dawson [**6**] based his view on two chief lines of evidence.

(Firstly) A few miles west of New Glasgow there is some appearance of an anticlinal fold in the conglomerate suggesting that the strata are developed along a deformed anticline and thus, countenance, the view that the strata may underlie the Coal Measures lying not far east. (Secondly) Dawson states that the fossils from the strata immediately overlying the conglomerate, are similar to those occurring in the Productive Coal Measures. Unfortunately, so far as known, no list of these fossils plant and fish remains have ever been published.

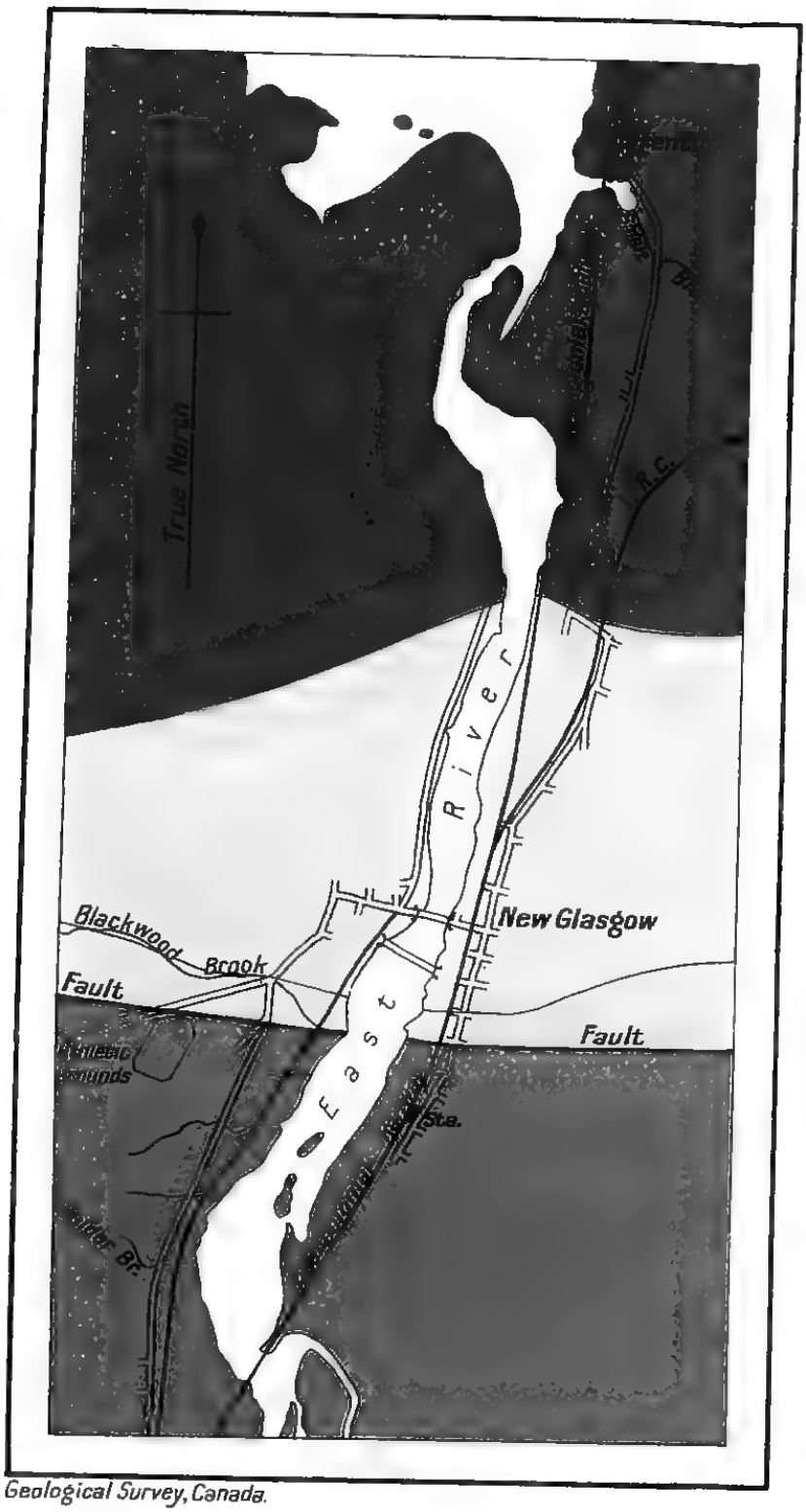
Pool [**12**] and Fletcher [**7** and **8**], contend that the New Glasgow Conglomerate is of post-Productive Coal Measures age because of two main reasons:—(firstly) the conglomerate uncomformably overlies the Millstone Grit and (secondly) no strata similar to the New Glasgow Conglomerate have been found beneath the Coal Measures in other parts of the Pictou coal field or elsewhere in Nova Scotia. Other lines of evidence support the general argument of Poole and Fletcher and, in the absence of any detailed statement of the palæontological evidence, appear to be quite conclusive.

DETAILED DESCRIPTION.

Logan has described the New Glasgow Conglomerate in the following terms [**11**].

"At the bridge of New Glasgow is exposed a series of conglomerates, which, in general colour, are between a brick-red and chocolate or indian-red, and whose enclosed masses, varying from the smallest pebbles to boulders of two feet in diameter, are for the most part, unmistakably derived from the red and greenish-grey sandstones, red shales and impure nodular limestones of the rock last described (Millstone Grit), some of them containing the

Geolog



Geological Survey, Canada.

New Glasgow

Feet

500 0 1000 2000 3000

Metres

0 500 1000

same vegetable organic remains. With these pebbles and boulders are associated a few from the rocks still lower down (pre-Millstone Grit). The whole are inclosed in a matrix of the same mineral character, constituting an argillo-arenaceous cement, which is also calcareous, and in the interstices of the boulders and pebbles is often observed a network of white calc-spar aiding to keep them together. There are interstratified in the rock, bands, from a few inches to several feet in thickness, of fine red sandstone and red shale, which serve to give assurance of the dip..... From a point a short distance above the bridge, to one much farther below, these conglomerates have a breadth of very nearly a mile, with a dip, which on the average is N. 3°-13° W., with a slope gradually diminishing from 50 °in the lower to about 30° in the upper part, and giving a total thickness of about 1,600 feet (490 m.)".

Along the bank of East river, the strata conformably overlying the New Glasgow Conglomerate are imperfectly exposed. On the west shore beyond a short concealed interval, occur fine-grained, pale yellow sandstones dipping northward at an angle of about 10°. On the east bank a bed of limestone outcrops that apparently occupies a place in the section intermediate between the conglomerates and the above mentioned pale coloured sandstones. About 3 miles (4·8 km.) to the east a similar limestone directly overlies the conglomerate and is succeeded by shales with a thin seam of coal. On the east shores of the river commencing at a place about 1,500 feet (450 m.) north of the conglomerate, where the shore bends to the east, and then northward to the mouth of Smelt brook, are exposures of sandstones and shales.

A generalized description of the overlying series has been given by Dawson [**5**] and is as follows:—

'1. .....the conglomerate is succeeded in ascending order by a grey concretionary limestone 20 feet (6 m.) thick, associated with sandstone and shale, and containing in some layers great number of the Spirorbis which I have described as *S. arietinus*.

2. Above this is a series of black shales and underclays with grey sandstones and some reddish and purple shales, and thin seams of bituminous shale and coal. These beds contain Stigmariae, Lepidodendra, Entomostracans, and fish remains; the fossils and the mineral character of the beds alike corresponding with those seen in the upper part of the Coal Measures south of the conglomerate. The thickness of these beds is about 400 feet (120 m.).

3. This series is succeeded by a thick grey sandstone holding Calamites, Calamodendron, trunks with aerial roots, etc., 30 to 50 feet (9 to 15 m.) thick. This appears at the mouth of Smelt Brook, and in several quarries to the eastward of that place.

4. Above this is a second series of dark shales and underclays, and bituminous shales associated with grey sandstones, and containing fossils similar to those of the

series below. It especially abounds in fish scales and Cythere; and several of the fishes are specifically identical with those of the upper part of the Middle Coal Measures, as seen in the southern trough south of New Glasgow. These beds are about 200 feet (60 m.) thick.

5. The beds up to this point may be considered the equivalents of the Middle Coal Measures, or of the upper part of them, and are now succeeded in ascending order by thick grey and reddish sandstones, and reddish and grey shales.....These may be regarded as belonging to the Upper Coal formation.....'

The New Glasgow Conglomerate in the form of a band about ½ mile (0·8 km.) wide, extends eastward from New Glasgow to the shores and islands of Merigomish harbour, distant about 6 miles (9·6 km.). The measures in this band dip uniformly northward at angles ranging between 45° and 60° along the southern edge of the band, and 15° to 30° along the northern margin. In the eastward extension of the formation sandstones become relatively more abundant and, on the islands in Merigomish harbour, sandstones predominate over the conglomerates. Westward of New Glasgow, the conglomerate outcrops over a band-like, area for a few miles, but beyond this, owing to folding, faulting, etc., the band-like character is lost.

East of New Glasgow, the conglomerate directly overlies measures that by all geologists have been ascribed to the Millstone Grit. West of New Glasgow, for a distance of about 1 mile (1·6 km.), the conglomerate rests on strata generally ascribed to the Millstone Grit, but beyond this point, the New Glasgow Conglomerate is separated by faults, from the adjoining strata on the south, or where not bounded by faults, rests on strata considered to be Devonian or older. Nowhere in the general district, does the New Glasgow Conglomerate come in direct contact with the Coal Measures.

East of New Glasgow, the New Glasgow Conglomerate and the underlying Millstone Grit dip, as stated by Logan, [**11**] "in such a way as, without other evidence, to induce the supposition that the one series overlies the other conformably". To the eastward, the Millstone Grit strata are displayed over a wide district but approaching New Glasgow, these measures because of the presence of an east-west fault are limited to a very narrow zone and are followed to the south, beyond the fault, by the Coal Measures.

In the partial geological section displayed in the vicinity of New Glasgow, along the west banks of East river, a few exposures of the New Glasgow Conglomerate dipping northward at an angle of 60°, occur above the highway bridge. Along the river side, above these out-

crops there is a concealed interval beneath which lies the lower portion of the New Glasgow Conglomerate, and the narrow strip of underlying Millstone Grit. The first exposures beyond, about opposite the New Glasgow railway station, belong to the Coal Measures. The strata there dip to the east at an angle of 45° and consist of a partly reddish, partly greyish grit containing angular fragments of quartz. The grit overlies a very fine-grained, pale-coloured sandstone. A few yards farther upstream the strata dip to the south at an angle of 55° and consist of fine-grained, pale grey sandstone streaked with thin beds or lenses of nearly black sandstone. Possibly the strata of these two exposures are separated by a fault.

A short distance to the south, at the mouth of a small brook, occur dark, nearly black, thinly bedded shales with interbeds of fine sandstone. The strata dip to the northeast at an angle of 60°. They are underlain by beds of rather hard, light grey, fine-grained sandstone which in the bank, in a space of 10 feet (3 m.) are seen to be folded along the strike through an angle of 60°. Plant remains occur in these beds.

About 40 yards (35 m.) to the south, the strata dip to the northeast at an angle of 30°. They consist of dark shales with thick beds of fine-grained, light grey sandstones in some of which plant and fish remains are abundant. Beyond this the shales become slaty, and at one place, for a space of a few feet, are nearly horizontal. Beyond this they resume their normal dip to the northeast.

Farther south, near the mouth of a small brook, similar strata outcrop, dipping to the east at angles of about 40°. Farther south at Calder brook and beyond are outcrops of the dark shales and light coloured sandstones dipping towards the east. In general the measures as displayed along this portion of the river, dip to the east but they are crumpled and doubtless are traversed by minor faults. That these beds belong to the Coal Measures does not appear to have ever been doubted by any geologist who has studied the district.

As already stated the New Glasgow Conglomerate and the underlying Millstone Grit as displayed to the east of New Glasgow dip and strike as though they were portions of one conformable series. To the west of East river it has been stated however, by various authorities that the New Glasgow Conglomerate unconformably overlies the

Millstone Grit. Hartley [**9**)], Fletcher [**8** p. 110], and Poole [**13**] have stated that this unconformity is visible along the course of Blackwood brook at points just to the west of the crossing of the highway paralleling the west bank of East river. Hartley and Poole unequivocally place the underlying strata in the Millstone Grit, but Fletcher states that possibly the beds belong to the Carboniferous Limestone series.

From the crossing of Blackwood brook by the highway, a road leads westward along the south side of Blackwood brook. From this road, ledges of the New Glasgow Conglomerate may be seen outcroping along the north bank of Blackwood brook. The coarse red conglomerate presents very few indications of bedding but appears to dip northward at an angle of about 40°. The conglomerate is exposed at intervals along the low bluff extending westward along the north side of the brook.

On the road leading westward, one or two imperfectly exposed outcrops of the underlying series occur, but they are better exposed farther to the west in the gully of a small waterway crossing the road near the northwestern corner of the Athletic Grounds. In this gully occur fine-grained sandstones, red in colour but irregularly streaked with grey. Towards the mouth of the small waterway, where it joins Blackwood brook, the sandstones dip to the northeast at an angle of 70°; a short distance up Blackwood brook, in the bed of the stream, the red sandstones are vertical; a short distance farther up stream, in the low bluff on the north bank, the sandstones are in direct contact with the New Glasgow Conglomerate and both sets of beds dip at very high angles to the northeast without any evidence of angular unconformity.

Thus even in the one place specifically cited by Hartley, Poole and Fletcher, there is no conclusive evidence of the existence of angular unconformity between the New Glasgow Conglomerate and the underlying strata presumed to be of Millstone Grit age. Where the exact contact of the two formations is visible, no angular unconformity is visible. The variations in the direction and value of the angle of dip of the two formations, are no greater in this neighbourhood than may be observed in the case of the conformable series of beds composing the Coal Measures. The conclusion is that west of East river, the New Glasgow Conglomerate overlies the Millstone Grit without angular

unconformity as it does in the cases described by Logan east of East river. In view of the evidence, the belief held by Dawson, that the New Glasgow Conglomerate is only a phase of the Millstone Grit does not seem impossible and might be considered as established if the palæontological evidence of the age of the beds overlying the New Glasgow Conglomerate had been fully stated and had then been found to bear out Dawson's contentions. But in spite of the seeming absence of any angular unconformity, that a disconformity does exist between the New Glasgow Conglomerate and the Millstone Grit seems to have been established by Logan, and, later, by Fletcher. How great an interval of time is represented by this disconformity is not altogether apparent and therefore the age of the New Glasgow Conglomerate can hardly be considered to be as yet established.

BIBLIOGRAPHY.

1. Dawson, J. W. Proceedings Geol. Soc. Lon., Vol. IV, pp. 272-281, 1843-45.

2. Dawson, J. W. Quart. Journ Geol. Soc. Lon., Vol X, pp. 42-47, 1854.

3. Dawson. J. W. Report on the geological structure and mineral resources of Prince Edward Island, 1871.

4. Dawson, J. W. Quart. Journ. Geol. Soc. Lon., Vol. XXX, pp. 209-218, 1874.

5. Dawson, J. W. Acadian Geology, Fourth Edition, Supplement to Second Edition, p. 35.

6. Dawson, J. W. Acadian Geology, Fourth Edition, pp. 322, et seq.

7. Fletcher, Hugh Geol. Surv. Can., Vol. II, 1886, part P.

8. Fletcher, Hugh Geol. Surv. Can., Vol. V., 1890-91, part P.

9. Hartley, E. Geol. Surv. Can., Report of Progress 1866-69, p. 66.

10. Lambe, L. M. Proceedings and Transactions, Roy. Soc. Can., Vol. V, sec. 4, p. 6, 1911.

11. Logan, W. E. Geol. Surv. Can., Report of Progress 1866-69, p. 13.

12. Poole, H.S . Proceedings and Transactions, Nova Scotian Inst. Sci., Vol. VIII, pp. 228-343, 1890-94

13. Poole, H. S. Geol. Surv. Can., Vol. XIV, 1905, part M, p. 11.

ANNOTATED GUIDE

NEW GLASGOW TO SYDNEY.

(G. A. YOUNG.)

Miles and Kilometres.

0 m.
0 km. **New Glasgow**—Alt. 29 ft. (8·8 m.). Leaving New Glasgow the Intercolonial railway crosses in a northward direction, the band of New Glasgow Conglomerate and enters the area of so-called Permian strata that stretches westward for about 75 miles (120 km.) along the shores of Northumberland strait. At a distance of about 7 miles (11·2 km.) from New Glasgow, the railway recrosses the band-like area of New Glasgow Conglomerate and enters the eastern extension of the Carboniferous area containing the Pictou coal field.

The Carboniferous strata of the area traversed by the railway belong almost entirely to the Millstone Grit. The measures are mainly reddish and greyish shales and sandstones with occasional beds of limestone and are folded and faulted. The Carboniferous area is low and rolling, and forms a narrow strip of country, 3 to 4 miles (5 to 6·5 km.) wide, extending from the sea and bounded on the south by a high rugged area having a general altitude of about 1,000 feet (300 m.). This upland rises abruptly from the Carboniferous area and is underlain by Silurian and older strata (Ordovician?) with which are associated bodies of intrusive and extrusive igneous rocks. The strata lie in a highly disturbed condition and, especially in the case of the pre-Silurian measures, are in many places schistose or otherwise metamorphosed.

Miles and Kilometres.

22·3 m. 35·9 km. **Avondale Station**—Alt. 151 ft. (46 m.). At Avondale, the railway enters the upland region of Silurian and older strata and follows a series of low valleys that cut completely through it. The elevated district extends in an eastward direction for about 25 miles (40 km.) and ends in a promontory on the sea coast. In the opposite direction, the highland joins the central upland area that extends, though with some interruptions, in a southwesterly direction for about 200 miles (320 km.) and forms the axis of the peninsula of Nova Scotia.

32 m. 51·5 km. **James River Station**—Alt. 255 ft. (77·7 m.). Shortly before reaching James River station, the railway leaves the upland area of disturbed Silurian and older measures and enters a low rolling area occupied by disturbed Carboniferous strata presumably belonging to the Windsor series. The low-lying Carboniferous area extends eastward to the sea. It is bounded on the north and east by the highlands of Silurian and older strata, while on the south it is limited by an upland area of strata belonging to the Riversdale-Union group.

41·5 m. 66·8 km. **Antigonish**—Alt. 20 ft. (6·1 m.). Beyond Antigonish the railway passes along the seaward border of the Carboniferous area. For a number of miles the low-lying country is underlain by measures supposed to belong to the Windsor series, but, farther east, the railway enters a bordering area of older Carboniferous strata.

70·2 m. 113·0 km. **Harbour au Bouche Station**—Alt. 271 ft. (82·6 m.). One mile (1·6 km.) beyond Harbour au Bouche, the railway enters a wide area of folded and faulted measures belonging to the Riversdale-Union group. These measures form the western shore of Cabot strait, distant a few miles to the east, and have been traced almost uninterruptedly as far as the neighbourhood of Windsor 150 miles (240 km.) to the southwest.

Miles and Kilometres.

80·2 m. 129·1 km. **Mulgrave Station**—Mulgrave station is situated on the western shore of Canso strait which separates the island of Cape Breton from the mainland. At this point the straits are about three-quarters of a mile (1·2 km.) wide. A ferry transports the trains across the straits to Point Tupper on Cape Breton island.

80·9 m. 130·1 km. **Point Tupper Station**—The island of Cape Breton has an area of about 3,600 square miles (9,360 sq. km.). About one half of the area of the island is underlain by Carboniferous measures while the remainder is occupied by Pre-Cambrian strata with minor areas of Riversdale-Union and Cambrian beds. The Pre-Cambrian rocks in general form upland areas rising to heights of from 500 feet to 1,500 feet (150 m. to 450 m.) above the sea. The Carboniferous strata occupy low-lying areas surrounding and penetrating the detached Pre-Cambrian uplands. The railway from Point Tupper to Sydney, follows in the main, a series of valleys in the Carboniferous areas but in places crosses low-lying areas of Cambrian and Pre-Cambrian rocks.

127·1 m. 204·5 km. **Grand Narrows Station**—Just before reaching Grand Narrows station the railway crosses Barra strait which connects Bras d'Or and Little Bras d'Or lakes. These two salt-water lakes are directly connected with the sea and, extending inland in a southeasterly direction, almost completely divide Cape Breton into two islands.

172·0 m. 276·8 km. **Sydney.**

SYDNEY COAL FIELD.*

INTRODUCTION.

(G. A. Young.)

The name, Sydney coal field, is applied to the area of Carboniferous strata fringing the northeastern coast of Cape Breton for above 30 miles (48 km.) from Cape

*See Map—Sydney Coal Field.

Dauphin on the west, to Mira bay on the east. The area occupied by these measures amounts to about 300 square miles (780 sq. km.) of which total about 50 square miles (130 sq. km.) is underlain by the Productive Coal Measures. In addition to the land area of the Productive Coal Measures, there is, by reason of the low seaward dip of the strata, a very considerable submarine area from which coal may be won.

The Sydney Carboniferous basin is notable for the splendid sections exposed along the coast and for the great thickness of the strata, which, in the vicinity of Sydney harbour, reaches approximately 12,600 feet (3,840 m.). The section is characterized by the apparent absence of pronounced stratigraphical breaks. In general, the geological structure is simple in form, the angles of dip low, and although a few prominent faults occur, the greater part of the field is free from them.

By reason of a series of low folds and certain indentations of the coast, the coal field is naturally divisible into six coal basins or districts. All of these with but one exception, contain, besides a number of minor seams, 5 to 8 seams of coal varying from 2 feet (0·6 m.) to 13 feet (3·9 m.) in thickness. The total thickness of coal in seams that may be workable varies in the five main basins from 23 feet (7 m.) up to 47 feet (14·3 m.). The coal is of a bituminous variety and in 1911 the total production amounted to above 4,900,000 tons. The individual seams are traceable for miles along the strike, in fact many of them are believed to extend throughout the whole length of the field. The individual seams vary somewhat in quality along the strike, change in thickness in a rather remarkable manner, and in some cases what is one seam in one locality becomes two in another because of the greatly increased thickness of an elsewhere relatively insignificant parting.

The fund of general geological information concerning the Sydney Carboniferous area is contained, almost entirely, in early reports by Charles Robb, and Hugh Fletcher, published by the Geological Survey in the '70s. and in a series of maps by Fletcher which are, in part, revisions of earlier editions. Important contributions to the geology of the district were made by Richard Brown at one time manager of a coal company operating in the field. The varied and striking palæobotanical material described by

Bunbury and Dawson was mainly collected by Brown, chiefly from the North Sydney area and in no small part from one shale bed overlying the Main seam. From this single horizon, it is stated by Brown, that over 90 plant species were obtained.

The Carboniferous strata of the district have been grouped and mapped under four divisions of which the highest, the Productive Coal Measures, embraces the youngest consolidated rocks in the region. The different divisions, in a general way, are displayed over long areas trending east and west, parallel to the coast line—the highest divisions bordering the coast, the lower divisions developed inland towards the south and resting on Cambrian and Pre-Cambrian strata. The Pre-Cambrian comprises plutonic, volcanic, and highly metamorphosed sedimentary strata; the Cambrian is mainly of sediments which are in part fossiliferous.

The Carboniferous area, bordered on the north and east by the Atlantic, is essentially a low, rolling country seldom rising higher than 350 feet (105 m.) above the sea while the Pre-Cambrian and Cambrian areas situated to the south and west are more broken and in part consist of long ranges of high hills rising abruptly from partly encircling Carboniferous lowlands, to heights of from 500 to 1,000 feet (150 to 300 m.) above sea level. The coast line is broken by bays and channels of the sea running inland in a southwesterly direction. One of the larger of these indentations is that of Sydney harbour situated towards the centre of the basin and forking towards its head into two arms each of which is continued inland by a long valley. Farther west, cutting through the Carboniferous lowland, are two long channels leading southwestward into the salt water Bras d'Or Lake which occupies so much of the central part of Cape Breton island.

The general southwesterly trend of the depressions occupied by the sea, of the courses of the axes of folds in the Carboniferous, and of the high ranges of Pre-Cambrian and Cambrian strata, is a marked feature. The presence of the Carboniferous over the lowlands that border and penetrate the high hills of Pre-Cambrian and Cambrian rocks, the overlapping of various divisions of the Carboniferous on these ancient strata, the relatively undisturbed attitude and the comparatively coarse nature of the bulk of the thick series of Carboniferous measures

are signs which point to the conclusion that the topography of the present day in some measure reflects that of early Carboniferous time.

The nearness to the old shore of the portion of the Carboniferous basin still preserved doubtless, in part at least, explains the great volume and general characters of the sediments. Possibly a considerable proportion of the supposed thickness may be explained as due to dip of deposition.

The general similarity of the Carboniferous measures as displayed in Cape Breton, to those on the mainland of Nova Scotia and over New Brunswick, along the southern and western edge of the Gulf of St. Lawrence; the resemblance of these beds to those developed in Newfoundland on the east side of the St. Lawrence gulf; and the occurrence of Carboniferous strata on the Magdalen islands situated towards the centre of the hydrographic basin, have lead various observers to believe that the Sydney Carboniferous area represents a remnant of the southern border of a once continuous basin of Carboniferous strata that may have occupied the greater part of the area of the Gulf of St. Lawrence.

The Carboniferous section of the Sydney field is customarily divided into the following groups, tabulated in descending order with approximate thickness as developed in the vicinity of Sydney harbour.

Productive Coal Measures	1,970 feet (600·5 m.)
Millstone Grit	3,625 feet (1,105·0 m.)
Limestone series	4,500 feet (1,371·6 m.)
Conglomerate series	2,525 feet (769·6 m.)
Total	12,620 ft. (3,846·7 m.)

The *Conglomerate series* consists essentially of red conglomerates, sandstones and shales. The conglomerates predominate and their waterworn pebbles and boulders are often of large size. Calcareous material in places forms the matrix of the conglomerates and occasional impure beds of limestone occur.

The *Limestone series* includes a great thickness of sandstone and shales, red and grey or green in colour, also conglomerate horizons, and many beds of limestone that frequently are fossiliferous. Only one bed of gypsum

is known to occur in this series in the neighbourhood of Sydney harbour though a few miles to the west and in other areas of the Carboniferous, gypsum forms an important member of the series.

The *Millstone Grit* is largely composed of coarse and fine, grey or green sandstones in part conglomeratic especially towards the base of the series, and shales usually dark in colour. In the eastern part of the field shales are relatively more abundant, are more largely red, and at least one important coal seam is present, whereas, to the west the shales are generally dark, are less abundant, the conglomeratic phases of the sandstone are more prominent and coal seams are absent or relatively unimportant.

The *Productive Coal Measures* are largely shales, commonly dark coloured but also in part red or green, and light coloured sandstones. Thin persistent beds of dark limestone form a characteristic feature of the lower portion of the division. In various measured sections, there is, on an average, 24 coal seams with a total average thickness of 46 feet (14 m.) of coal.

The thickness of the three lower divisions varies from place to place. At the eastern end of the field, on the shores of Mira bay, the Millstone Grit has an estimated thickness of about 5,700 feet (1,740 m.); on Sydney harbour, the measured thickness is 3,625 feet (1,105 m.); while farther west, the thickness decreases to about 2,000 feet (610 m.). The Limestone series shows a more marked variation in thickness, ranging from 4,000 feet (1,220 m.) or more at the foot of Sydney harbour to less than 900 feet (275 m.) on the east side of George river only 4 miles (6·4 km.) to the west. The Conglomerate series exhibits a still wider range of thickness, since in places it is altogether wanting.

Of the great volume of Carboniferous strata, by far the greater part is apparently of continental origin and practically only in the case of the Limestone series with its fossiliferous limestones and shales, is there positive evidence of normal marine origin of any of the strata. The evidence found in the Productive Coal Measures of the former existence *in situ* of forest growth; the abundant plant remains found in the Millstone Grit and their occurrence in a fragmentary state in the Conglomerate series; the character of, and the channeling phenomena, etc. exhibited by the sandstone beds that form so large a part

of the whole section; and other lines of evidence, all indicate that throughout the greater part of the period of deposition, the Sydney area was above sea level though presumably forming part of a low lying coast.

On palæobotanical, stratigraphical and lithological grounds, the Productive Coal Measures have been correlated with the divisions of the same name in the other coal basins of Nova Scotia. The Millstone Grit presents the same general features in all the basins. These two representatives of the Pennsylvanian, as well as portions of the underlying series, in many ways present a remarkable parallelism with the equivalent horizons of the famous Joggins section 200 miles (320 km.) away. Owing to the encroachment of the sea, the highest beds of the Productive Coal Measures, if ever present, are no longer visible. In other Nova Scotia coal fields, this series is generally succeeded by strata classified as Upper or Newer Coal formation (Dawson) or Permo-Carboniferous or Permian (Fletcher).

The Limestone series from which, at Sydney, a comparatively meagre fauna has been obtained, has generally been regarded as in some measure the equivalent of the Windsor series and therefore of Mississippian age. The Conglomerate series has not been with any certainty correlated with horizons in the coal basins on the mainland of the province, and, indeed, there are good reasons for believing that under this name, in different districts, entirely different formations have been grouped.

By some the whole Carboniferous section at Sydney has been described as a strictly conformable series but, Fletcher, who devoted the work of a lifetime largely to the Carboniferous of Nova Scotia, always held that a break existed between the Millstone Grit and the Limestone series but agreed on the other hand, that the divisions between the Millstone Grit and the Productive Coal Measures, and between the Limestone series and the Conglomerate series, were in the main, arbitrary ones. The same authority for a while, was inclined to maintain that the measures of the two lower divisions were,in different fields, in part at least contemporaneous, but at a later date, Fletcher, as he extended his work over the various areas of Carboniferous in Nova Scotia, abandoned this idea and came to regard the Conglomerate series as a distinct

group, the lowest of the Carboniferous horizons or, possibly, belonging to the Devonian in part or in whole.

As a result of recent investigations in the Sydney field, Hyde (see later pages) divides the original Limestone series in two and links the upper subdivision with the Millstone Grit, and the lower with the typical Windsor series.

The geological structure of the Sydney Carboniferous area is of a comparatively simple type. Over large areas the strata dip with low angles ranging in value from 5° to 20°, and the greater part of the district is free from faulting. The whole basin is divisible into four subordinate synclinal basins whose axes in the west, strike N.E. and S.W. but towards the east have a more nearly E.-W. trend. These folds with their limbs in most cases dipping at low angles, apparently all pitch seaward so that along the coast, the highest Carboniferous strata, the Productive Coal Measures, form, save for blank spaces due to indentations of the sea, a nearly continuous band striking northwesterly at right angles to the courses of the axes of folding.

On the western side of the field, the basin is bounded by the bold range of the St. Anne hills composed of Pre-Cambrian and Cambrian strata rising to heights of from 500 to 1,000 feet (150 to 300 m.). In places the hills rise directly from the shore of the Great Bras d'Or channel; in other places they are separated from the waters by a narrow fringe of the Limestone series; while, towards the northeast, they are divided by a pronounced fault from a small basin of the Productive Coal Measures and older divisions of the Carboniferous.

Separated from the St. Anne range by the Great Bras d'Or channel, lies Boularderie island, about 25 miles (40 km.) long, and representing a synclinal basin mainly of Millstone Grit, this being the most westerly of the four synclinal basins of the field. To the southeast of the island and separated from it by St. Andrew channel, rise the Boisdale hills composed of Pre-Cambrian and Cambrian strata. This range extends in a S.W.-N.E. direction and represents the axial portion of an anticlinal that strikes through the northeastern extremity of Boularderie island. The Boisdale hills are in part flanked by strata of the Conglomerate series but in places members of the Limestone series repose directly on the ancient strata of the range of hills. A seeming overlap of the Carboniferous along the southeastern flanks of the range has been considered by

some as evidence of a fault striking along the southeast side of the hills and it has been held that this fault continues to the northeast through the Carboniferous basin, perhaps along the winding, river-like channel of the Little Bras d'Or. No direct evidence has been produced of the existence of such a fault and it seems more probable that the structure is due to overlapping and not to faulting.

The next anticlinal axis passes through Point Edward at the extremity of the projection separating the two arms of Sydney harbour. In a southwest direction, the course of this axis is indicated by the zone of the Conglomerate series lapping around the Pre-Cambrian strata of the Coxheath hills. Towards the northeast, beyond Point Edward, the anticlinal axis follows a course that swings to the E.N.E. and passes beneath the waters of Bridgeport basin. A fault has been described by Fletcher as extending southwestward up the valley of Sydney river on the south side of Coxheath hills. This fault in the neighbourhood of the town of Sydney has been supposed to abruptly change its direction and to run thence with a southeasterly course forming the northern boundary of a subordinate synclinal basin of strata mapped as Millstone Grit but which on palæobotanical grounds was considered by Dawson as possibly of the age of the Productive Measures.

Farther eastward, an anticlinal axis strikes inland from Cape Percy (North Head) with a W.S.W. course. This anticline apparently dies away inland. It is followed on the south by the synclinal basin of Cow bay which also dies away inland.

The southern margin of the western portion of the field when represented in plan on a map, indicates very clearly the position of the anticlinal axes of the Coxheath, Boisdale and Ste. Anne hills—the Carboniferous projecting southwestward in the form of synclinal basins between the axial areas of Pre-Cambrian strata. Towards the east, the basin-like structure is not so strikingly exhibited and the south boundary is formed by Millstone Grit strata resting directly on Cambrian and Pre-Cambrian beds except in the extreme east where beds of the Limestone series form the basement and are separated by faults from the Millstone Grit measures.

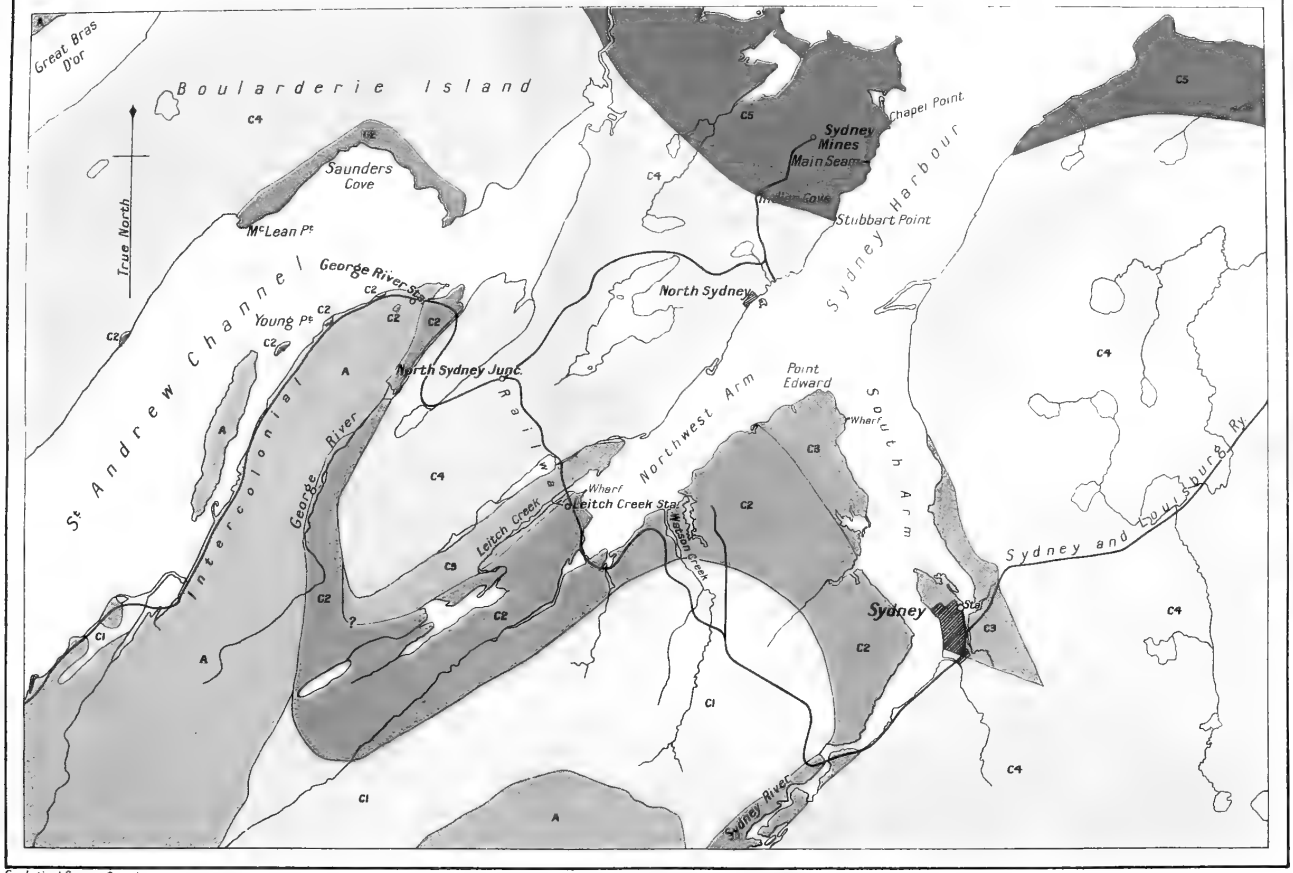
NOTE ON THE FLORA OF THE COAL MEASURES.

(David White.)

The palæobotany of the Sydney coal field, in Cape Breton, engaged the attention of the pioneers in palæontology in Canada. The flora was first examined by Sir Charles Lyell who, in his "Travels in North America", catalogued the fossils plants found by him at the mines. The paper by C. J. F. Bunbury, who carefully described about 50 species from Sydney in the collection of Richard Brown, is a cornerstone in the Palæozoic palæobotany of North America. Two of the excellently illustrated species, *Neuropteris rarinervis* and *Neuropteris cordata* [*Neuropteris scheuchzeri*] are most characteristic and omnipresent in the Alleghany formation and its contemporaries in the coal fields of the United States. They are present also in the lower part of the Coal Measures of many of the basins of Europe, and specimens indistinguishable from those of the second species found in Cape Breton are assocciated with some of the coals of central China. In the Appalachian trough the two species occur sparingly also in the Mercer group and within the synchronous topmost part of the Kanawha formation, but they are unknown in the older beds of the Upper Carboniferous. *Dictyopteris obliqua* and *Odontopteris subcuneata*, species founded by Bunbury, are present also in Europe as well as in the United States, where they are characteristic of a restricted zone.

The flora of the Sydney coal field was further elaborated by Dawson in a number of papers. About 115 species are reported from this coal field, but, unfortunately, the descriptions are generally so meagre and the illustrations so inadequate in most cases that the palæontologist is hardly able, merely from the examination of the reports, satisfactorily to determine the positions of the plant-bearing beds in the cosmopolitan time classification. However, it would appear from the comparison of Dawson's list that the species as a whole, cited as belonging to the "Middle Coal formation" of Cape Breton, are of slightly later date than those noted from the same formation in the Joggins section, being approximately referable to either the "transition series" or the basal portion of the Upper Coal Measures in Great Britain, and to the base of the European Stephanian, which


Geo



Geological Survey, Canada

Sydney

Miles 1 0 2 4

Kilometres 1 0 2 4 6

Legend

Carboniferous

- C5 Coal measures
- C4 Millstone grit
- C3 Point Edward formation
- C2 Windsor series
- C1 Conglomerate series

Pre-Carboniferous

- A Cambrian and Pre-Cambrian

embraces the greater part, at least, of the Alleghany formation in the Appalachian trough of the United States. Evidently several widely removed plant-bearing horizons have furnished material for the list, and it is not unlikely that some of the lower of these may be as old as the uppermost portion of the Pottsville, or perhaps the Middle Coal Measures of Europe. As belonging to the "Upper Coal formation" Dawson mentions a number of species some of which are clearly Stephanian and as high as the upper part of the Alleghany in the Appalachian coal fields.

THE CARBONIFEROUS SECTIONS ON SYDNEY HARBOUR*.

(J. E. Hyde.)

INTRODUCTION.

The section at Sydney shows the Mississippian (Sub-Carboniferous) formations, especially the Windsor series, succeeded by three Pennsylvanian (Coal-Measures) formations, the Point Edward formation, the Millstone Grit and the "Coal Measures". No other locality at present known in the eastern part of Canada shows all of these formations both so characteristically developed and with their stratigraphic succession uncomplicated by faulting or folding. Exception is not made even to the Joggins section. The Sydney section is the only section so far known in which beds with the *Leaia* fauna (the Point Edward formation which is believed to represent the Riversdale and Union) can be seen lying on the Windsor series, and overlain by the Millstone Grit. This section has determined the stratigraphical position of this fauna, although its approximate age has been known for several years.

*See Map—Sydney.

The section is as follows, from the top downward:—

Pennsylvanian system.

Productive Coal Measures.—Sandstones and shales with a number of workable coal seams and several thinner ones. Plant remains are abundant in the series; upright tree trunks are not infrequent in the shales, and roots and rootlets in position are abundant. *Anthracomya* and ostracods are abundant in the black shales associated with the coals and much the same fauna is also found sparingly in an occasional thin bed of limestone..... 1,970 ft. (600·5 m.)

Millstone Grit.—A massive, yellowish to grey, coarse, feldspathic sandstone with numerous pebble beds in the middle and lower portions; occasional thin beds of coal occur..... 3,625 ft. (1,105 m.)

Point Edward formation.—(Name new; formerly considered the top of the "Limestone series.") Alternating sandstones and shales, which are predominantly red or purplish in colour. The sandstones are characterized by cross-bedding produced by the translation ripple. Occasional limestones occur which with the shales are sometimes mud-cracked. Gypsum beds occur occasionally. A fauna consisting almost wholly of *Leaia*, a few species of *Anthracomya* and ostracods occur in the beds of grey shale. This fauna is also found, in part at least, in the Riversdale and Union formations near Truro. The Point Edward formation is correlated in a general way with those formations. According to Robb, the thickness is about..... 700 ft. (213 m.)

Mississippian system.

Windsor series.—Marine limestones and grey or red shales with occasional sandstones. This formation is not so well developed or so well shown in the Sydney section as it is in other localities on Cape Breton island. The total

thickness, which is here given, is only about half as great as the figure assigned by Robb to the same beds..... 600 ft. (183 m.)

The following members of the Windsor series arranged in descending order, can be distinguished:—

a. Oölitic marine limestones with red shales and coarse sandstones. The limestones are marine but with a limited fauna. Thickness about..... 211 ft. (64·3 m.)

b. Reddish shales, sandstones and conglomerate with beds of limestone which carry a fauna almost wholly of ostracods; only a few small marine lamellibranchs and gastropods are present. Thickness about ..... 188 ft. (57·3 m.)

c. Sandy shales, sandstone and conglomerate, predominantly red, with at least four marine limestones, not well shown. Thickness estimated at about..... 200 ft. (61 m.)

Age uncertain, probably Mississippian, formerly considered the lower part of the Sub-Carboniferous "Limestone series."

Red and purple sandy shales, sandstones and conglomerates all loosely coherent, with occasional thin beds of barren limestone. Pebbles up to several inches in diameter are present but they are, on the whole, not as coarse as in the formation next below. This formation was included by Fletcher in his "Sub-Carboniferous Limestone series" because of the presence of an occasional limestone bed. These are not known to carry fossils. The thickness given by Robb, which is here adopted, is probably much too large..... 2,633 ft. (802·5 m.)

Carboniferous Conglomerate series.—This was so called by Fletcher but its age is unknown. It consists of red and purplish conglomerates, differing mostly from the overlying beds in their greater coarseness.

In degree of consolidation, distribution, amount of folding, etc., it belongs to the overlying series and is probably not far removed from it in age. It rests on highly metamorphosed Cambrian and Pre-Cambrian rocks and was evidently deposited in basins between hills of these old rocks, or on the slopes of such hills. Thickness, according to Fletcher..... 2,525 ft. (769·6 m.)

The rocks about Sydney harbour lie in a broad anticline which pitches to the northward. The axis of this anticline runs along the western side of the broad peninsula which lies between the east and west arms of the harbour. The section is best shown beginning with the oldest rocks on the brooks south of the west arm of Sydney harbour, thence continuing along the east shore of this arm to Point Edward. From there it can be followed, after a long interval covered by the water, along either the east or west shores of the main harbour.

DETAILED DESCRIPTIONS.

The Basal Division of the Windsor Series.—At Point Edward post office are located the quarries of the Nova Scotia Steel and Coal Co., one of the principal sources of limestone for the iron furnaces. At the road crossing at the end of the branch railway leading to the quarries is the southern margin of the belt of Windsor rocks. To the southward, in the distance, rise the high Coxheath hills of resistant Pre-Cambrian and Cambrian metamorphic and plutonic igneous rocks. These hills are probably of pre-Carboniferous age. The broad belt of rather low land intervening between these hills is underlain by the slightly resistant, loosely consolidated conglomerates and sandstones of the lower part of the Carboniferous section which overlap on to the Pre-Cambrian hills and dip northward. These conglomerates constitute Fletcher's Conglomerate series and the lower part of his Limestone series.

Proceeding westward, down the road to the shore, the first rocks seen are the topmost beds of the loosely consolidated sandstones and conglomerates just mentioned.

They are here much finer than to the southward nearer the source of the material of which they are composed. Overlying these sandstones is the basal bed of the Windsor series proper, a massive grey limestone 10 feet (3 m.) thick which forms a prominent point projecting into the bay.

In the following paragraphs, the beds of the basal member (c) of the Windsor series are numbered in ascending order, as they occur along the shore northwards.

1. Massive grey oölitic limestone, which forms a prominent point projecting into the bay. Occasional fossils, chiefly *Producti*, occur. This is bed 51 of Robb's section at Sydney..... 10 ft. (3 m.)
2. Red clay shales with thin limestones, very poorly shown along the shore just north of the last point; about....40 ft. (12·2 m.)

(Beds 3 to 8 inclusive are exposed on the shore just south of the old wharf.)

3. Coarse sandstone and conglomerate with red shale.....4 ft. (1·2 m.)
4. Grey nodular limestone, greenish and black shale.....8 ft. 10 in. (2·7 m.)
5. Thin, soft, coarse sandstone with plant remains.....2 ft. 6 in. (1·4 m.)
6. Bluish grey nodular limestone; fossils abundant and surrounded by concentric deposits of limestone which are apparently original. One of the best fossils beds of the section.....2 ft. 4 in. (0·7 m.)
7. Sandy shales with abundant concentric nodules containing *Producti*.....2 ft. 2 in. (0.6 m.)
8. Light grey, thinly bedded limestone with *Producti*.....9 ft. (2·7 m.)

The next set of beds in the section are exposed in the old Louisburg quarry situated 75 metres inland at the end of an abandoned road.

9. Thinly bedded, grey, finely oölitic limestones with *Producti* abundant in pockets and layers. These beds overlie those (No. 8) seen on the shore but it is not exactly known whether or not the basal beds in the quarry are shown on the shore. It is reported that limestone was once quarried here for use in the building of Louisburg. Thickness at least..... 13 ft. (3·9 m.)

Leaving the Louisburg quarry ,and continuing eastward up the hill, along the strike of the quarry bed, past the old lime kiln, and from there along a more northeasterly course descending into a small shallow stream valley the next two beds may be noted.

10. Massive pink limestones, single bed 2 ft. 2 in. (0·6 m.)
11. Massive very finely oölitic limestone 6 ft. 6 in. (2·0 m.)

Crossing the marshy stream in the shallow valley, the line of section continues up the hillside over a covered interval to the base of the main quarry.

12. Covered, but known to carry near the middle a massive limestone 9½ feet thick (2·9 m.) and at the top 15 feet (4·5 m.) of coarse sandstone with plants, the top of which can be seen at one point in the quarry. About..... 70 ft. (21·3 m.)

The following beds are exposed in the large quarry of the Nova Scotia Steel and Coal Company.

13. Grey oölitic limestone with concentric nodules, resting on the sandstone mentioned under No. 12..... 2 ft. 7 in. (0·8 m.)
14. Sandy shale with abundant hard concentric limy nodules in which fossils occur..... 1 ft. 6 in. (0·4 m.)

15. Massive oölitic limestone, fossils very rare except in basal two feet where *Productus* is fairly common. In places the limestones show the concentric structure prominently and in such a manner as to suggest that it is an original structure of the limestone. This is the topmost bed of division C of the Windsor limestones.....32 ft. 8 in. (10 m.).

Fauna of the Windsor Series.—The fauna of the Windsor series as developed at Sydney differs considerably from the fauna found in these limestones at Windsor, N.S., but several of the species are identical and there is no question as to the general equivalence of the beds. On the other hand, many species appear which have not been recorded from Windsor. These differences appear to be due, in considerable measure, to the variation of the fauna from point to point. The following notes are the results of a preliminary study and are subject to considerable revision and amplification. The propriety of using some of the specific names here adopted is very doubtful. For example, "*Dielasma sacculus*" Martin, is certainly not present. But the form here so designated has almost always been so referred to, and a different name cannot be adopted without much discussion.

The faunas of the three members of the Windsor series differ considerably. That of the uppermost member is a pure marine fauna with corals, *Productus*, *Schuchertella*, *Camarotœchia*, *Spirifer*, *Spiriferina*, *Composita*, "*Dielasma sacculus*", several species of marine lamellibranchs and gastropods, and other species.

That of the middle member is also marine but evidently developed under restricted or special conditions. Several species of ostracods, *Spirorbis*, two or three species of small aviculoid and alate lamellibranchs, a small gastropod and the Foraminiferal species (?) *Nodosinella priscilla* Dawson, comprise the whole of the fauna so far observed.

The fauna of the lower member, as developed near Point Edward Post Office, evidently existed under more nearly typical marine conditions than did that of the middle member but no such diversified fauna has been observed as is found in the upper member. Whether this is due to biotic conditions or difference in age cannot as yet be stated. The lower member is marked by numerous species of *Productus* and by the alate lamellibranchs.

Rather striking, also, is the restriction of the faunules in the several beds and the appearance of different species in these beds. This tendency, the limitation of and difference in the faunules in successive beds, is believed to be due to varying biotic conditions.

Several species are common to the lower and upper members of the Windsor, among them *Productus* cf. *arseneaui*, *Productus laevicostus*, *Pugnax dawsonianus*, and *Dielasma sacculus*.

One species only has been found common to the Point Edward formation and the Windsor series, the ostracod here called *Beyrichiopsis granulata* var, which is so strikingly distinct as to be easily recognized. It occurs in several beds of the Windsor, ranging from the basal bed of the lower member into the middle of the middle member.

In the whole Windsor series of this section, there is only one bed and one locality, so far observed, where fossils are abundant. This is in the upper member. Usually they are scarce, and not infrequently they are to be obtained only after a long and patient search.

Following is a list of the species obtained in the lower member at the Point Edward Post Office locality. The numbers at the top of the columns are the ones used to designate the beds in the detailed section already given.

——	Basal Part.	Upper Part.					
	1	1	6	7	9	14	15
Serpulites annulatus Dawson	....	x	....	....	....	....	....
Spirorbis sp	....	....	....	....	....	x	....
Productus cf. arseneaui Beede	....	....	x	x	....	....	x
Productus auriculispinus Beede	x	....	....	....	....	....	....
Productus dawsoni acadicus Beede	....	....	x	....	....	....	....
Productus laevicostus White	....	....	....	x	....	....	....
Productus tenuicostiformis Beede	....	....	....	....	x	....	x
Productus sp	....	x	....	....	....	x	....
Pugnax dawsonianus Davidson	....	x	....	....	....	....	....
'Dielasma sacculus Martin'	....	x	....	....	....	....	x
Aviculopecten sp	....	....	x	....	....	....	....
Aviculopecten cf. debertianus Dawson	....	....	....	....	x	....	....
Leptodesma sp	....	....	x	x	....	....	....
Leiopteria dawsoni Beede	....	....	....	....	x	....	....
Gastropod gen. et sp. (*a*)	....	....	....	x	....	x	x
Gastropod gen. et sp. (*b*)	....	....	x	....	....	....	....
Orthoceras sp	....	....	x	x	....	....	....
Endolobus avonensis Dawson	....	....	x	....	....	....	....
Ostracods	x	....	x	x		x	x
Beyrichiopsis granulata J. and K. var	x	....	....	....	....	....	....

Point Edward Post Office to the Quarantine Station on Point Edward.—The branch railway from the limestone quarries at Point Edward post office, runs southward to join the main line of the Intercolonial railway. This branch railway passes on the western side of the north-easterly pitching anticline whose position is marked to the south by the Pre-Cambrian area of the Coxheath hills around which the Lower Carboniferous beds are symmetrically disposed. Leaving the quarries, the railway passes through a belt of northerly and gently dipping red and purple, sandy shales, sandstones and conglomerates underlying the Windsor series and forming part of the original Limestone series. Farther south, the branch railway enters the area of reddish conglomerates of the Conglomerate series which extends southward over and around the Pre-Cambrian rocks of the Coxheath hills.

From the point of junction of the branch railway and the main line, the Intercolonial railway runs in a northeasterly direction towards and then around the head of the Northwest Arm of Sydney harbour. Along this course the railway passes over the Carboniferous strata in ascending order as they occur on the western limb of the Point Edward anticline. For some distance west of the railway junction, the underlying strata belong to the Conglomerate series; beyond this occur the measures of the Limestone series outcropping along the eastern shore and about the head of the Northwest Arm. The strata dip to the northwest at angles of 5° to 20°. In the vicinity of Leitch Creek station, the measures belong to the Windsor division of the Limestone series; beyond this, on the western shore at the head of Northwest Arm, the strata belong to the Point Edward division which farther west along the railway are succeeded by Millstone Grit beds.

Proceeding by boat from Leitch Creek station, northward down the waters of Northwest Arm, low outcrops of the Point Edward formation may be observed in the banks on the west. These dip to the west under the Millstone Grit which forms the high hills a few hundred metres beyond the shore. The Point Edward formation is only shown for a short distance, when it passes entirely below the Millstone Grit. The contact is a sharp one, and is moderately well shown. From the contact northward to beyond North Sydney, outcrops of the Millstone Grit are more or less continuous on the west bank. On the east

shore, the contact between the Windsor series and the Point Edward formation lies between the two closely located light houses. Northward from these lights occasional low outcrops of the Point Edward formation may be seen, in ascending order. Rounding Point Edward, outcrops in descending order continue southward to the landing pier at the Quarantine station.

The Point Edward Formation.—On the farther side of the first little bay north of the landing pier, a bed of dark grey shale furnishes the typical fauna of the Point Edward formation, including *Leaia*. At the point beyond, mud-cracked limestones, red shales and reddish and purplish sandstones typical of the Point Edward formation, may be observed. The sandstones are characterized by cross bedding, the result of translation ripples. Plant fragments are abundant and branches several feet in length are not unusual. There are also peculiar vertical tubes distributed abundantly through the sandstones, the origin of which is uncertain.

Section of Millstone Grit and Coal Measures in the Vicinity of North Sydney. The Millstone Grit and Coal Measures form a thick, conformable series outcropping on the western shore of Sydney harbour and Northwest Arm from Limestone creek on the south to Cranberry head on the north. Throughout this whole section, which has a length of about 7½ miles (12 km.), the strata dip at angles of from 5° to 15° to the north and north-northwest. The total thickness of measures displayed is about 5,350 feet (1,830 m.) of which the upper 1,725 feet (525 m.) belong to the Coal Measures. The Millstone Grit strata are almost entirely grey sandstones which towards the base of the formation are conglomeratic, while at the summit they are interbedded with variously coloured shales. One coal seam, with a thickness of about 2 feet (0·6 m.) occurs in the Millstone Grit towards the top of the formation. The Coal Measures consist of grey sandstones, dark and variously coloured shales, thin limestones and numerous coal seams which individually are as much as 6 feet (1·8 m.) thick, and have a combined thickness of nearly 42 feet (12·8 m.).

The exposures of Millstone Grit to the southward of North Sydney are monotonously alike. The upper part of the formation is well exposed along the shore to the northward of the town and the strata there are quite

typical of the whole formation except that conglomeratic beds are not present. The contact of the Millstone Grit with the Coal Measures is a conformable one and is excellently shown. The somewhat arbitrarily chosen boundary between the two formations is indicated by a rather abrupt change from the light colour of the sandy measures of the Millstone Grit to the much darker, shaly strata of the Coal Measures. An upright tree trunk, several feet in height is shown (in 1912) in cross section a short distance beyond the contact.

Immediately north of the piers at Indian Cove, and in the shales overlying the Indian Cove coal seam, abundant

Coal measures, Sydney, N.S. Looking north from "Main seam" outcrop.

fern remains may be found. Long Stigmaria roots are found in these shales with rootlets radiating in all directions in position as they grew. In the coarse sandstones overlying this shale bed, are abundant upright Calamite stalks up to two feet in length. Continuing up the shore, a monotonous succession of sandstones, red shales, grey shales, coals, etc., is traversed. The red shales are mud-cracked; the grey shales commonly carry rootlets; the black shales associated with the coals usually show abundant ostracods and *Anthracomya*. An occasional thin bed of limestone is exposed, one bed of which is known to carry fragmental fish remains in abundance.

Just before the " main seam" is reached, upright tree trunks and roots are found in abundance in one of the shale beds. The "main seam" is indicated by old workings and excavations, but its very top may be seen if tidal conditions are favourable. The shales overlying it have furnished many species of plants. A few metres beyond the main seam, *Anthracomya* and ostracod s, may be found in black shales in an old excavation in the cliff.

BIBLIOGRAPHY.

1. Brown, R.....Quart. Journ. Geol. Soc. Lon., Vol. I, pp. 207–203, 1845: Vol. II, pp. 293–6, 1846: Vol. III, pp. 257–60, 1847: Vol. IV, pp. 46–50, 1848: Vol. V, pp. 354–60, 1849: Vol. VI, pp. 115–133, 1850.

2. .....Coal Fields and Coal Trade of the Island of Cape Breton, London, 1871.

3. Bunbury, C. J....Quart. Journ. Geol. Soc. Lon., Vol. III, pp. 423–437, 1847: Vol. VIII, pp. 23–26, 1852.

4. Dawson, W. J....Quart. Journ. Geol. Soc. Lon., Vol. XXII, p. 95, 1866.

5. .....Canadian Naturalist, Vol. VIII, p. 431, 1863.

6. .....Geol. Surv. Can., Fossil Plants of the Lower Carboniferous and Millstone Grit, 1873.

7. .....Acadian Geology.

8. Fletcher, Hugh...Geol. Surv. Can., Report of Progress, 1875–76; Report of Progress, 1876-77

9. .....Geol. Surv. Can., Descriptive Note of the Sydney Coal Field, 1901.

10. Gilpin, E.....Proceed. and Trans. Nova Scotian Inst. Sc., Vol. VIII, pp. 435–8, 1895.

11. Lesley, J. P.....Amer. Journ. Sci. and Arts, 2nd ser., Vol. XXXVI, p. 179, 1863.

12. .....Proceed. Amer. Phil. Soc., Vol. IX, pp. 93–109, 1865.

13. Robb, C.....Geol. Surv. Can., Report of Progress, 1872–73: Report of Progress, 1873–74: Report of Progress, 1874–75.

ANNOTATED GUIDE.

SYDNEY TO GEORGE RIVER STATION.

(G. A. YOUNG.)

Miles and kilometres.

0 m.
0 km.

Sydney.—Leaving Sydney station, the Intercolonial railway, before passing out of the city crosses the fault line forming the boundary between the area of Carboniferous Limestone series on which the city is built and the wide area of Millstone Grit extending far to the south and east. After leaving the city proper, the railway passes close to the shores of the estuary of Sydney river. Occasional outcrops of Millstone Grit occur along the shore, the strata dipping to the southeast at angles of from 15° to 35°. Strata of the Limestone series, also dipping to the southeast, are exposed on the opposite side.

Three miles (4·8 km.) from Sydney, the railway crosses Sydney river. The low valley of the river extends with this character for a number of miles to the southwest and is floored with strata of the Carboniferous Limestone series, the measures dipping to the southwest. At the crossing of Sydney river, the band of the Limestone series is less than ½ mile (0·8 km.) wide and the railway in a short distance passes into an area occupied by the Carboniferous Conglomerate series. The strata of the Conglomerate series are arranged in anticlinal form about a ridge of Pre-Cambrian strata which rises several miles southwest of the railway. The reddish conglomerates, sandstones and shales of the Conglomerate series dip at low angles, away from the central ridge of Pre-Cambrian rocks and are flanked on the east, north and west by apparently conformable strata of the Limestone series.

Three miles (4·8 km.) beyond the crossing of Sydney river, the railway passes over a low summit situated approximately on the anticlinal axis of the fold in the Carboniferous strata,

Miles and Kilometres.

and begins a traverse of the northwestern limb of the anticline. In a distance of about 2 miles (3·2 km.) from the summit, the railway again enters the encircling area of the Limestone series and shortly approaches the shores of the Northwest Arm of Sydney harbour around the head of which the railway passes. The low valley at the head of the Northwest Arm is floored by strata of the Limestone series dipping to the northwest at angles of from 15° to 25°.

10·4 m. 16·7 km. **Leitch Creek Station**—Alt. 10 ft.(3 m.). A short distance beyond Leitch Creek station, at the crossing of Leitch creek, a view up the valley shows the ridge of the Boisdale hills rising to altitudes of 600 to 800 feet (180 to 249 m.). The Boisdale hills are composed of Pre-Cambrian rocks and form the western boundary of the Carboniferous basin. The Carboniferous Limestone measures extend up the valley of Leitch creek and there repose directly on the Pre-Cambrian rocks without any intervening strata of the Conglomerate series.

A short distance beyond the crossing of Leitch creek, the railway passes through cuttings in reddish shales and sandstones possibly belonging to the Point Edward formation which in places lies between the Limestone series and the Millstone Grit. Just beyond this point, where the railway skirts the shores of a small lake, the area of Millstone Grit strata forming the summit of the western limb of the anticline, is entered upon. Small cuttings in Millstone Grit strata occur along the railway. The measures dip to the northwest at angles of 10° to 20°. The Millstone Grit strata form a ridge exending in a northeast-southwest direction and in which the strata are arranged in a shallow syncline. To the southwest, the Millstone Grit strata are encircled by measures of the Limestone series which rest on the Pre-Cambrian rocks of the Boisdale hills. To the northwest, the Millstone Grit

Miles and Kilometres.

beds dip beneath the Coal Measures of the North Sydney area.

12·9 m. 20·8 km. **North Sydney Junction**—Alt. 159 ft. (48·5 m.). North Sydney Junction is situated approximately on the axis of the synclinal fold traversing the Millstone Grit area. From this point, the waters of St Andrew channel are visible to the northwest, with the low wooded heights of Boularderie island beyond, while above these are visible the highlands on the western side of Great Bras d'Or. These highlands, distant about 9 miles (14·5 km.) rise to altitudes of 900 feet (275 m.) and form the western boundary of the Sydney Carboniferous basin. Boularderie island is mainly occupied by Millstone Grit strata arranged in a shallow syncline with strata of the Limestone series occurring at intervals along the southeastern and northwestern shores. The anticlinal axis separating the Boularderie Island syncline from the North Sydney syncline is, in a general way, the prolongation of the axis of the Boisdale hills.

Leaving North Sydney Junction, the railway descends towards the valley of George river. The Boisdale ridge rises on the further side of the river valley and after passing a small lake, a quarry working in Pre-Cambrian crystalline limestone is visible on the side of the ridge. The western side of the valley of George river is floored with strata of the Carboniferous Limestone series dipping to the east. The total thickness of this series as developed in this neighborhood is small as compared with the development on the shores of Sydney harbour. Possibly the decreased thickness is due either to faulting or to an overlap of the Millstone Grit.

The railway crosses George river near its mouth and enters the narrow area occupied by the Limestone series. The railway passes close to the shore around the northern end of

Miles and Kilometres.

the Boisdale ridge and after leaving the area of the Carboniferous Limestone series, it crosses Pre-Cambrian granite which extends westward beyond George River station.

16·6 m
26·7 km. **George River Station**—Alt. 37 ft. (11·3 m.).

GEORGE RIVER.*

(G. A. Young.)

INTRODUCTION.

The line of the Intercolonial railway eastward and southward from George River station affords an opportunity of examining a part of a section transverse to the axis of the Boisdale hills at the northern end of this upland. This range of hills is largely underlain by Pre-Cambrian and Cambrian strata with detached areas of Carboniferous measures outcropping along their flanks.

The Boisdale hills follow a S.W.–N.E. course for a distance of about 30 miles (48 km.) and vary in width from 6 miles (9·6 km.) in the southern portion to about ½ mile (2·4 km.) at the northern end. Along their northwestern side, the hills rise steeply, in places abruptly, from the waters of Bras d'Or lake, to heights of 600 feet (180 m.) to 900 feet (275 m.) above sea level. Along their southeastern side, the hills in the north are bounded by the lowlands of the Sydney Carboniferous basin, while towards the south they rise directly from the shores of East bay, a northeasterly extension of Bras d'Or lake.

The strata outcropping in the Boisdale hills have been mapped and grouped by Fletcher [**1**] as follows:—

Carboniferous	Carboniferous Limestone series. Carboniferous Conglomerate series.
Pre-Carboniferous	Cambrian. Pre-Cambrian, George River series. Pre-Cambrian, granite, gneiss, schist, etc.

*See Map—George River Station.

The Pre-Carboniferous strata, at first considered to represent metamorphosed Carboniferous measures intruded by granitic bodies, were next thought to be of Silurian age, and finally, by Fletcher were mapped and described as divisible into Lower Silurian (*i. e.* Cambrian) and Pre-Cambrian. Later still Matthew subdivided the Cambrian into five divisions and placed in the Cambrian certain strata previously considered to be of Pre-Cambrian age.

The Pre-Cambrian strata as mapped by Fletcher, occupy by far the larger part of the area of the Boisdale hills. The Carboniferous beds occur only in the form of a narrow, discontinuous border. The Cambrian beds are mainly confined to a long, narrow zone which in the north forms the western margin of the upland but in the south, extends from side to side of the Pre-Cambrian area.

The Pre-Cambrian was divided by Fletcher into two groups. One of these was termed the George River series and because of its lithological characters was supposed to be the equivalent of the Grenville-Hastings series of Quebec and Ontario. This view was adopted by Matthew also. As described by Fletcher, the George River series consists of crystalline limestone, quartzite, mica schist, hornblende schist, etc., interleaved with granitic and gneissic rocks. The strata in most places, are inclined at high angles and are highly metamorphosed. The series was regarded as essentially of sedimentary origin and was believed to be younger than, and to rest unconformably on the associated granitic rocks. This view of the relations existing between the sedimentary series and the plutonic rocks was doubltess based on the beliefs, held in the 70's at the time the field work was performed, regarding the relations existing in the typical Laurentian areas of Quebec. Recent examinations made of some typical sections of the George River series indicate, however, that the granitic rocks unmistakably cut and are younger than the George River series. The correlation on lithological grounds of the George River series with the Laurentian (Grenville-Hastings) of distant Quebec is perhaps no longer justifiable. But the various points of resemblance existing between the Pre-Cambrain of Cape Breton and the original Laurentian, are worthy of note.

The George river series as mapped by Fletcher is confined to three, long, detached areas situated along the southeastern flank of the Boisdale hills. These areas border the great central mass of the ranges regarded by Fletcher as essentially occupied by granite but including large and small areas of rocks that in some cases possibly belong to the George River series and in others to the Cambrian. As already stated, it is now advocated that the granitic rocks are younger than the George River series. It is assumed, therefore, that the Pre-Cambrian of the Boisdale hills consists of the remnants of one or more series of limestones, quartzites, etc., and possibly deformed volcanics, intruded by bodies of granitic rocks. In the extreme northern portion of these hills, the granites form relatively large, homogenous areas from which offshoots extend into the older, bedded series.

The Pre-Cambrian age of the above described assemblage of strata has been established by Fletcher, who stated that Cambrian conglomerates hold rock fragments similar to varieties of rocks in the Pre-Cambrian, and that the Cambrian is nowhere cut by the granites. Examples of the actual unconformable superposition of the Cambrian on the Pre-Cambrain have been described by Fletcher and Matthew. In general, however, the two rock groups are in contact along faults.

The Cambrian measures as mapped by Fletcher, form a long, narrow band extending nearly the whole length of the Boisdale hills. As described by Fletcher, the Cambrian consists of a series of sediments and, also, a group of igneous rocks generally described under the name of 'felsites.' On an earlier map, a considerable area of these igneous rocks is unquestionably included in the Cambrian. On a later map, a portion of these igneous rocks is mapped separately. The relation of these igneous rocks to the Cambrian sediments is not specifically described by Fletcher, nor is it very apparent on what grounds certain 'felsites' were mapped as Cambrian while others were assigned to the Pre-Cambrian. Matthew has definitely grouped certain of the igneous rocks with the Cambrian, including some that by Fletcher were considered Pre-Cambrian.

Matthew has subdivided the Cambrian, on paleontological and lithological evidence, into five groups. The

following table is a condensed form of one published by Matthew [**2**, p. 69].

		Equivalents in Great Britain.
Ordovician.	Bretonian.	Llandeilo. Arenig.
		Tremadoc. Dolgelly.
Cambrian.	Johannian.	Maenterog. Ffestiniog.
	Acadian.	Menevian.
		Solva.
Basal Cambrian.	Etcheminian. Coldbrookian.	Caerfai Pebidian.

The *Coldbrookian* is described by Matthew as essentially composed of volcanic rocks comprising flows and tuffs. In places it is found lying unconformably upon the Pre-Cambrian with a coarse conglomerate at the base. At one locality only, are fossils described as occurring in the Coldbrookian. At this locality, on Dugald brook, about 20 miles (32 km.) southwest of George River station, the Coldbrookian is only 315 feet (96 m.) thick. The lower portion is of feldspathic sandstones with layers of conglomerate. The upper portion consists of amygdaloids and felsites. Above these occur members of the Etcheminian division. The fossiliferous strata lie midway in the section and are about 30 feet (9.1 m.) thick. Six species of brachiopods and two of ostracods are described by Matthew [**2**, p. 72]. The two ostracods occur also in the overlying Etcheminian accompanied by brachiopods very similiar to those found in the Coldbrookian.

The typical region for the Coldbrookian series is in southwestern New Brunswick, where, so far as is known, the

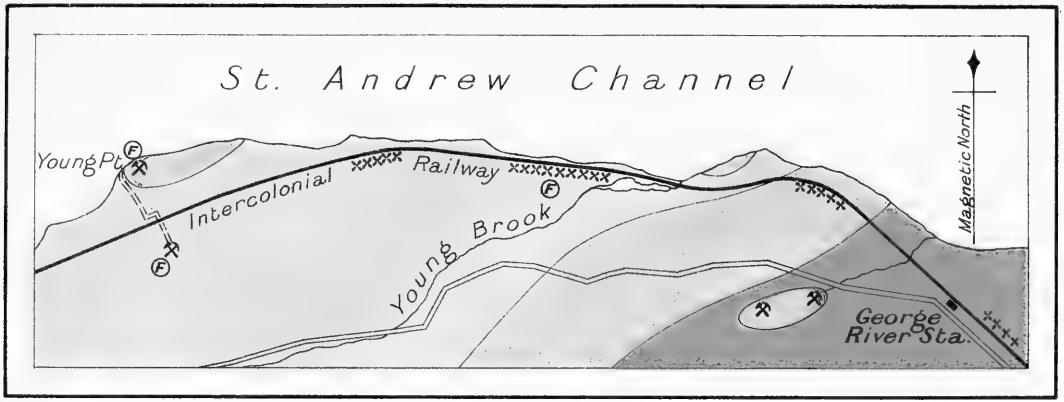
rocks of this group are all igneous and have generally been considered to belong to the Pre-Cambrian. The correlation of the strata in the Boisdale Hills has been based, (1) on supposedly similar stratigraphical relations and (2) on similarity in appearance.

The *Etcheminian* is described as essentially a sedimentary formation divisible into a lower and upper division. The lower division consists largely of red and grey slates and sandstones with conglomerate beds. The upper division is composed mainly of grey, fine and coarse, shales and slates. Both divisions are fossiliferous and besides a number of species of brachiopods and osteracods, Matthew has listed a trilobite "apparently related to Asaphus" (*Holasaphus centropyge*), a Paradoxoid trilobite and one of the genus Solenopleura.

The *Acadian* division consists chiefly of dark grey slates. It is unfossiliferous in the Boisdale hills area. The *Johannian* is composed mainly of grey slates, sandstones and quartzites and has produced some fossils, among them, *Paradoxides forchhammeri*, and a number of inarticulate brachiopods. The *Bretonian* division is chiefly formed of dark grey and black slates; among the few fossils that have been found are species of Asaphellus, a typical 'Tremadoc' genus. On the Mira river, the Bretonian is much more richly fossiliferous and contains faunas, strictly comparable to the Scandinavian Upper Cambrian and Lower Ordovician.

Matthew gives [**2,** p. 52) the following estimate of the thickness of the Cambrian as developed respectively in the Boisdale Hills area and in the Mira River valley not many miles to the east.

	Boisdale hills.	Mira river.
	Feet.	Feet.
Bretonian	500	500
Johannian	1,200	2,000
Acadian	200	800
Etcheminian	500	3,000
Coldbrookian	300	very thick.



Geological Survey, Canada

George River Station

Feet
1000 0 1000 2000 3000 4000

Metres
100 0 200 400 600 800 1000

(Scale of map is approximate)

Legend

- **Carboniferous** Windsor series
- **Cambrian**
- Mainly volcanic rocks
- Granite
- ××× Rock cuts on railway
- Quarry
- Ⓕ Fossils

DETAILED DESCRIPTION.

The Intercolonial railway from George River station to Young point closely follows the shores of St. Andrew channel. To the north, across the waterway, lies Boularderie island mainly underlain by Millstone Grit measures with strata of the Limestone series outcropping along the shores. On the south side of the railway the land rises quickly to heights of 600 feet (180 m.) to 700 feet (215 m.) above the sea.

The geological section developed along the railway is transverse to the axis of the Boisdale hills and cuts across them at their northern end. At the eastern end of the section, the Pre-Cambrian granite is exposed. Proceeding westward, the granite is followed, according to Matthew, by Coldbrookian and then by Etcheminian strata.

The rocks in the first cutting east of George River station consist of pink granite traversed by a number of parallel dykes of diabase dipping at high angles. The granite is presumably of Pre-Cambrian age; the dykes are possibly much younger. The dykes vary greatly in width and individually send parallel off-shoots into the granite. The rocks are much fractured and, in places sheared. As a result, the rocks along the walls of some of the dykes resemble a conglomerate. Referring to the basal conglomerate of the Etcheminian, Dr. Matthew makes the following statement [**2**, p. 17]; "In the railroad cutting at George River station the contact of these conglomerates with the syenite (i.e., granite) can be seen at several places. They fill hollows in the syenite."

A small outcrop of granite occurs on the south side of the railway, a short distance west of the first brook crossing the railway west of George River station. This is the last exposure of granite. The rock does not outcrop on the shore. It is visible at a number of points on the eastern slopes of the valley in which flows the small brook just crossed. The granite body is known to extend for an indefinite distance southward. The western boundary of the granite probably lies about 100 yards (90 m.) west of the isolated exposure on the railway. The relations existing between the granite and the rocks exposed in the first rock cut to the west of the brook are not known. Nowhere in the immediate neighborhood has the granite or its apophyses been found penetrating the rocks of this cut.

They may, therefore, be younger than the granite and possibly are of Cambrian age.

The first rock cut to the west of the brook exposes weathered and, in places, sheared igneous rocks. Two main rock types are present, one is represented by dense greenish black and reddish rocks apparently approaching an andesite in composition. The other type is fine-grained, greenish black in colour, and is of the composition of a diabase. The diabase closely resembles the dykes of this rock cutting the Pre-Cambrian granite in the first rock cut and is thought to be the same rock.

At the eastern end of the rock cut are a few exposures of an andesite tuff, while at the west end, there is a small exposure of conglomerate. Throughout the length of the cut, the andesite and diabase alternate. The relations of the diabase to the andesite are not known. The conglomerate at the west end of the rock cut, is penetrated by the diabase and presumably the diabase also cuts the andesite either in the form of dykes or sills.

Approaching the west end of the rock cut, on the seaward side, are exposures of reddish, shale-like rocks probably representing much decomposed andesite. On the south side, at the west end of the rock cut, is a small exposure of conglomerate composed of somewhat angular rock fragments of small size in a quartzite matrix. The rock fragments closely resemble the andesites. This conglomerate and the diabase that cuts it, mark the end of exposures of igneous rocks. The same igneous assemblage occurs on the beach north of the railway and the exposures there also terminate with an outcrop of conglomerate. In the hill country to the southwest of the railway are outcrops of the same igneous rocks as occur on the railway.

The relations existing between the igneous rocks and the succeeding Cambrian sediments is not directly known. Both on the shore and along the railway, the exposures of the two classes of rocks are separated by a concealed interval. On the shore, the concealed interval is about 250 feet (76 m.) in width. Beyond it to the west are continuous exposures of green and reddish grits, sandstones and shales of Cambrian age. The sedimentary beds are faulted and closely folded. It is assumed that they are separated from the igneous rocks on the east by a fault. The conglomerate at the west end of the rock cut possibly represents the base of a series of rocks younger than the

andesites. The conglomerate may mark the base of an older Cambrian series brought by the assumed fault against the Cambrian strata to the west. If the conglomerate is of Cambrian age, it is evident that the diabase is also of Cambrian or younger age. This would then, also be true of the dykes cutting the granite in the first rock cutting.

The igneous strata of the railway cut belong to a limited area along the border of the Cambrian basin from which they seem to be separated by a fault . There is no direct evidence that they are not of Pre-Cambrian age and they may be older than the Pre-Cambrian granite. Dr. Matthew writing of the basal conglomerates of the Etcheminian, makes the following statement [**2,** p. 17] regarding the rocks exposed along the railway cut just traversed: ".....the conglomerates are seen to rest on dark purplish-grey, fine grained felsite similar to those of Long island and presumably of the Coldbrookian terrane....." The so-called Coldbrookian on Dugald brook, 20 miles (32 km.) to the southwest, contains a fossiliferous zone with Cambrian fossils.

To the west of the above described rock cut, approaching Young brook, a few exposures of Cambrian sediments occur close to the railway. From the culvert over Young brook, the Cambrian measures are visible in low cliffs extending eastward along the shore. The strata consist of grey, green and reddish slates, sandstones and fine conglomerate faulted, folded and crumpled. Fossils, almost all inarticulate brachiopods belonging to the genera Lingulella and Lingulepis, are abundant in these strata along the shore west of Young brook and are present, though less common, in some of the strata east of the culvert. Regarding these strata, it has been stated [**2,** p. 17] that the reddish and purplish beds belong to the lower division of the Etcheminian and are cut off by a fault at Young brook from the grey strata of the upper division exposed to the west along the shore and railway as far as Young point.

In the first rock cut beyond Young brook occur greenish shales and sandy beds with others of lighter coloured sandstone, also some dark shales. Near the beginning of the rock cut, a synclinal crumple is visible. Beyond this, the strata dip in a fairly constant direction, inland, at high angles.

At about the centre of the rock cut are a number of thin beds (8 inches and less) of fine, grey sandstone containing

brachiopods, etc. The same general strata are also exposed in the low cliff along the shore on the north side of the railway.

In the next rock cut are exposed crumpled dark slates accompanied by torn bands of fine sandstone. A short distance further, a small rock cut passes through dark greenish slates with very thin beds of sandstone.

To the south of the railway, the same general strata are exposed with a general strike towards the northeast but faulted, crumpled and closely folded. On the shore, to the north of the railway, the shaly strata are also crumpled and torn.

In the small quarry on the north side of the railway at Young point, is exposed a face of dark slates interbedded with sandstone bands carrying fossils, *Lingulepis roberti* is the common fossil. The strata are bent into an anticlinal fold. On the higher slopes of the hill, above the quarry opening, are outcrops of greenish slate and in places, coarse and fine sandstone beds some of which are fossiliferous. The strata are much disturbed. In places they are minutely crumpled; in other places they lie in small folds whose axes are separated by intervals of 5 feet to 10 feet (1·5 to 3 m.). The strike is, as before, fairly constant and follows a general northeast course.

At Young point there is a small quarry in Carboniferous limestone, which fills a depression in the eroded surface of the highly tilted Cambrian shales. Similar pockets of Mississippian limestone with fossils occur on the eastern side of the valley south of the railway near George River station and elsewhere. The limestone is fossiliferous and at Young point, mingled with the Carboniferous types are Cambrian forms derived from the underlying strata. The following note has been prepared by J. E. Hyde:—

"The following species have been obtained from the Windsor limestone resting on the old land surface near George River station, at Young point and in the two small quarries back of the station. Those species which are marked with an asterisk (*) are the more characteristic of the faunule, although only one, *Dielasma sacculus*, is very abundant. By far the greater part of these species were obtained at Young point but the limestone at the two other pockets carry the same fauna, in so far as it is developed. Six of the 12 species have not been observed in the Point Edward or Sydney section, namely 1, 6, 7, 8, 9, and 11 "

1. Auloporoid coral sp. undt.
2. *Serpulites annulatus Dawson.
3. Productus sp.
4. Schuchertella sp.
5. *"Dielasma sacculus Martin."
6. Edmondia cf. magdalena Beede.
7. *Leptodesma sp. cf. Leiopteria acadica Beede.
8. *Pteronites sp.
9. *Loxonema sp.
10. Orthoceras cf. indianense Hall.
11. *Conularia planicostata Dawson.
12. Ostracods.

The Cambrian consists of purplish and greenish shales with thin layers and beds of purplish weathering sandstone and grit. Similar strata outcrop along shore for about 1,000 feet (300 m.). The beds are traversed by small faults and dip in various directions usually at high angles. The folding and faulting is such that practically everywhere the same horizon is exposed and a three to four-foot bed of coarse sandstone or fine grit in various attitudes is exposed at a number of places. Beyond this, the above measures give place to greenish shales crenulated and closely folded.

At Young point some of the sandy beds are rich in brachiopods. From these measures Dr. Matthew [**2,** p.19] has listed the following species:—

Leptobolus atavus.	Billingsella retroflexa.
Lingulella selwyni.	Holasaphus centropyge.
Lingulepis roberti.	A paradoxidoid trolobite.
Obolus discus.	A eurypterid? crustacean.

This is the type locality for the trilobite genus *Holasaphus*, and specimens of the typical species (*cranidia* and *pygidia* are quite abundant in the shale just north of the quarry.

Regarding the fossils from this locality, Matthew states [**2,** pp. 18-19] that on examining an earlier collection it was thought that they were of Lower Ordovician age. But as a result of a personal visit to the locality, he became convinced that "the beds, in place of being at the summit of the Cambrian, are towards its base. and are in fact of the lower division of the Etcheminian." Recently the

writer and Dr. P. E. Raymond obtained *Paradoxides forchhammeri* from the Young Point beds. The finding of this species, as pointed out by Dr. Raymond to the writer, indicates that the measures belong to the highest of the Middle Cambrian Paradoxides zones.

The assignment of the Young Point beds to the upper portion of the Middle Cambrian is of especial interest. Prior to the recognition of *Paradoxides forchhammeri*, Dr. Matthew on faunal and lithological grounds assigned the Young Point beds to a horizon about in the middle of the Etcheminian. The fauna of the Etcheminian and the Coldbrookian as stated by Dr. Matthew [**2,** p. 72] are very similar. It would appear therefore that in Cape Breton, the oldest known Cambrian is not older than the Middle Cambrian. As far as the evidence presented along the line of section traversed goes, it would appear that the Cambrian is altogether a sedimentary series and that the so-called Coldbrookian is of Pre-Cambrian age.

BIBLIOGRAPHY.

1. Fletcher, Hugh....Geol. Surv. Can., Note on the Sydney Coal Field, Cape Breton. Map-sheets, Nos. 133,134 and 135.
2. Matthew, G. F....Geol. Surv. Can., Cambrian Rocks of Cape Breton, 1903.

ANNOTATED GUIDE.

GEORGE RIVER STATION TO ANTIGONISH.

(G. A. Young.)

Miles and Kilometres.

0 m.
0 km. **George River Station**—Alt. 37 ft. (11·2 m.). From George River station the Intercolonial railway runs eastward around the northern end of the Boisdale hills, and keeping close to the shores of St. Andrew channel, passes along the foot of the western slope of the range of hills. A short distance beyond George River station, the railway enters an area of Cambrian strata which form the western slopes of the hills. The Cambrian beds extend as a comparatively

Miles and Kilometres.

narrow band southeastward throughout the whole length of the Boisdale hills.

At Young point, about 1½ miles (2·4 km.) from George River station, Long island becomes visible from the railway. A small island lying north of Long island is composed of horizontal limestone of the Carboniferous Limestone series. Long island which has a length of about 2½ miles (4 km.), is in part occupied by disturbed sedimentary beds, in part by fine-grained igneous rocks possibly partly extrusive and partly of intrusive origin. The sedimentary strata of Long island are in part at least, of Cambrian age and as described by Matthew, the igneous rocks are of the same age.

Beyond Young point the railway closely follows the shore of the sound separating Long island from the mainland. The bold, eastern rock face of Long island is formed almost entirely of igneous rocks. On the mainland, along the railway are cuttings in dark Cambrian slates and sandstones closely folded along north-south axes. The Cambrian strata extend to the top of the high, steep ridge which rises almost directly from the shore to altitudes of 600 to 700 feet (180 to 215 m.). About opposite the southern end of Long island, the Pre-Cambrian strata which bound the Cambrian on the east, approach closely to the shore and then recede.

5·6 m.
8·9 km.

Barrachois Station.—Just south of Barrachois station the railway passes through a long cutting in dark slates. These slates are apparently unfossiliferous but on lithological and structural grounds are supposed by Matthew to belong to the Bretonian and to be of Upper Cambrian age. A short distance beyond, the railway crosses the mouth of McLeod brook. The Cambrian measures extend southward up the valley of McLeod brook as a narrow band about ½ mile (0·8 km.) wide and bounded on both sides by Pre-Cambrian rocks. This band of Cambrian strata continues southward across a low divide and thence down the valley of Indian brook almost to the shore of East bay

Miles and Kilometres.

which bounds the Boisdale hills on the south. This band of Cambrian strata has a length from the mouth of McLeod brook southward, of about 17 miles (27 km.). In the McLeod brook basin the Cambrian strata apparently belong to the Bretonian (in part lower Ordovician); in the Indian brook basin, all horizons of the Cambrian are represented. Along the eastern side of the band-like area, the Cambrian strata are faulted against the Pre-Cambrian; on the western side, in places at least, the older Cambrian beds rest in an unfaulted condition on the Pre-Cambrian.

After crossing McLeod brook, the railway enters a small irregular area of Carboniferous Conglomerate reposing on Cambrian strata. Beyond this the Cambrian measures continue along the shore for a distance of about 3 miles (4·8 km.) until, opposite a low projecting point, they are succeeded by gently dipping red sandstones and conglomerates of the Carboniferous Conglomerate series. From this point, the Carboniferous measures form an almost continuous band of variable width extending southwestward along the shore of St. Andrew channel. Inland these measures underlie a low, broken country abutting against the steeply rising, high ridges of Pre-Cambrian rocks consisting chiefly of granite associated with relatively limited amounts of "felsite," quartzite, crystalline limestone, etc.

The Carboniferous strata dip in general to the northwest at angles of 10° to 30°. Across St. Andrew channel on Boularderie island, distant about $2\frac{3}{4}$ miles (4·4 km.), strata of the Limestone series outcrop, dipping in the same general direction beneath the Millstone Grit strata which, in the form of a syncline, occupy the greater part of the island. The Limestone series is characterized by beds of gypsum, white cliffs of which are visible from the railway. Rising above the hills of the island, are high hills [altitude 700 to 900 feet, (215 to 275 m.)] of Pre-Cambrian rocks on the mainland across

Miles and Kilometres.

Great Bras d'Or channel on the far side of Boularderie island.

11 m. 17·7 km. **Boisdale Station.**—Near Boisdale station and at intervals beyond, rock cuttings in the red conglomerates and sandstones of the Carboniferous series occur along the railway. The Carboniferous strata continue along the shore for about $5\frac{1}{2}$ miles (8·8 km.) or until about opposite the end of Boularderie island, where sedimentary strata, possibly of Cambrian age outcrop near the shore. From this point to Shenacadie station, several miles further on, the Carboniferous strata are confined to a narrow band, and the front of the high ridges of Pre-Cambrian rocks closely approaches the shore.

19·8 m. 31·8 km. **Shenacadie Station.**— From Shenacadie station onwards to Grand Narrows the railway continues to follow the shore line. Along this stretch the shore is bordered by a narrow strip of strata assigned by Fletcher to the Carboniferous Limestone series. These measures on the inland side are bounded by strata of the Conglomerate series occupying a zone that widens southwards at Grand Narrows to a maximum width of about 3 miles (4·8 km.). The underlying Conglomerate series consists of red conglomerates, sandstones and shales with some bituminous shales, beds of limestone and occasional thin seams of impure coal. The overlying Limestone series contains besides variously coloured sandstones and shales, beds of limestone (in places fossiliferous) and beds of gypsum. Presumably the Limestone series is to be correlated with the Windsor series.

The gypsum does not occur in the narrow strip of the Limestone series traversed by the railway but it is present on the opposite shores of Little Bras d'Or lake. The flat-topped hilly country of the opposite shore is, in part occupied by Pre-Cambrian rocks occurring in two areas but in the main it is occupied by measures of the Conglomerate series lying in a broad anticlinal.

Miles and Kilometres.

Along the shore, at intervals, occur patches of the Limestone series which seem to lie along the continuation of the synclinal axes that traverse Boularderie island to the north.

Approaching Grand Narrows, cliff faces in gypsum are visible on the opposite shore.

28·3 m. 45·5 km. **Grand Narrows**—At Grand Narrows the railway crosses the strait, about 650 yards (590 m.) wide, connecting Little Bras d'Or lake with Great Bras d'Or lake. These two salt water lakes extend southwesterly through the centre of Cape Breton and almost divide it into two islands. The combined lakes have a length of 60 miles (96 km.) and an area of 360 square miles (935 sq. km.). Long bays continued inland by low valleys, are a feature of the lakes and these with other characters indicate that the lake basin, in part at least, represents a system of drowned valleys.

After crossing the bridge at Grand Narrows, the railway for a few miles follows the northern shore of Great Bras d'Or lake. Inland rise low hills of the Carboniferous Conglomerate series, while along the shore occurs a comparatively narrow zone of the Limestone series, the strata dipping southerly with angles of 15° to 40°. Cuttings in red conglomerates, shales and gypsum occur along the line of railway for about four miles (6·4 km.), to where the railway line leaves the shore. In a distance of a little over one mile (1·6 km.) the railway again touches the shore at the head of McKinnon harbour, a winding narrow bay about 3 miles (4·8 km.) long.

34·6 m. 55·5 km. **McKinnon Harbour Station**—Inland from McKinnon harbour a low, hilly country underlain by gypsum and the associated strata of the Carboniferous series, extends northwesterly for about 4 miles (6·4 km.) to the shores of the St. Patrick channel, a long (25 miles or 40 km.), narrow, irregular bay extending southwesterly from Little Bras d'Or lake. St. Patrick channel is mainly bordered by areas underlain by the Limestone series, but along the northwestern

Miles and Kilometres.

shore these areas are narrow and are limited inland by the Carboniferous Conglomerate series or by detached areas of Pre-Cambrian rocks. The Pre-Cambrian strata form bold ridges and hills, in some cases only a couple of miles in diameter, which in some instances rise to heights of 1,000 feet (300 m.). In general, the strata of the Conglomerate series surround the high Pre-Cambrian areas, and in places the Carboniferous strata form uplands comparable in heights with those occupied by the Pre-Cambrian.

Westward from McKinnon Harbour station, the railway at first follows close to the shores of the bay, then leaves the shore for a space, and afterwards again approaches the water; beyond this the railway strikes inland and after a distance of about 1½ miles (2·4 km.) again comes to the shores of the lake towards the head of an inlet which the railway crosses. Along this portion of the railway, cuts and natural exposures of gypsum are visible at intervals, while in other places, the minutely broken and irregular topography suggests that considerable areas are underlain by gypsum. At intervals, views are afforded of the numerous low islands and the inlets occurring in this part of the lake. To the south, across a wide bay studded with islands, may be seen the bold ridge of North Mountain formed of Pre-Cambrian strata rising abruptly to heights of 500 to 700 feet (150 to 215 m.) above the low, encircling Carboniferous areas.

About 4½ miles (7·2 km.) beyond McKinnon Harbour station, the railway as already mentioned, crosses an inlet. This inlet extends inland beyond the railway for about 1 mile (1·6 km.). The head of this inlet is separated from St. Patrick channel by a space of low-lying ground only about 400 yards (360 m.) wide and as the railway crosses the valley of the inlet glimpses are obtainable of the high ridges on the north side of St. Patrick channel. A short distance beyond this, Alba station is reached.

Miles and Kilometres.

40·3 m. 64·8 km. **Alba Station**—A short distance beyond Alba, the railway departs from the lake shore to again come upon it after a distance of about 3 miles (4·8 km.) where it passes the heads of several small bays extending inland from North Basin, itself an arm of an irregularly shaped inlet known as Denys basin. At various points as the railway passes within sight of North basin, the steeply rising north end and northwest flank o the ridge of North Mountain is visible. At Orangedale station, the railway passes around the head of North basin and looking up the valley at the head of the basin, the high ridge of Craignish hills, about 5 miles (8 km.) distant, may be seen rising from the Carboniferous lowland. All of the low country, 7 to 9 miles (11·2 to 14·5 km.) broad, between the Craignish hills on the northwest and North Mountain on the southeast, is occupied by the gypsum, limestone and associated strata of the Carboniiferous Limestone series.

45·4 m. 73·0 km. **Orangedale Station**—About $1\frac{1}{2}$ miles (2·4 km.) beyond Orangedale station the railway skirts the head of Seal cove, the last point on the railway from which the waters of Bras d'Or lake are visible. Beyond Seal cove, the railway passes into the valley of River Denys, a winding sluggish stream. The railway follows the river for some distance, then crosses it, and 2 miles (3·2 km.) beyond passes River Denys station.

Between Orangedale and River Denys, the railway gradually approaches North Mountain and a number of uninterrupted views are afforded of the steep northwest face rising from the low-lying area underlain by the Limestone series. The ridge of North Mountain rises to heights of between 600 and 800 feet (180 to 240 m.) and is formed of Pre-Cambrian rocks. A portion of the Pre-Cambrian is composed of crystalline limestone, quartzite and various types of schists associated with "felsites". Such rocks occur

Miles and Kilometres.

in detached areas but the bulk of the Pre-Cambrian is formed of granite and which is intrusive into the limestone, etc.

53·3 m. 85·7 km. **River Denys Station**—Alt. 72 ft. (21·9 m.). From River Denys station the railway runs southwestward up the valley of Big brook along the foot of the slope of North Mountain. The valley of Big brook is underlain by strata of the Limestone series dipping at angles of 20° to 70° to the west beneath a synclinal basin of Millstone Grit and perhaps younger strata lying about midway between the Pre-Cambrian areas of North Mountain on the east and the Craignish hills on the west. In the lower part of the valley of Big brook, the Craignish hills, distant 6 to 8 miles (9 to 13 km.), are visible but as the railway ascends the valley the view of these hills is cut off by the intervening ridge of Millstone Grit. Towards the head of Big brook valley, the bounding ridge of younger Carboniferous strata on the west attains altitudes comparable with those of North Mountain along the foot of which the railway continues to run.

From the head of Big brook valley the railway crosses a summit (altitude, 286 feet or 87·2 m.) and enters a watershed draining southward to the Strait of Canso. As the railway descends, a view is afforded to the westward across the wide low valley of River Inhabitants which flows from the northwest. The valley of the river and the lower slopes on both sides are underlain by strata of the Limestone series and perhaps older divisions of the Carboniferous dipping in various directions and traversed by a series of east-west and north-south faults. The higher lands on the western side of the valley are occupied by measures that have been mapped as Devonian but which are believed to include at least some members that are the equivalent of the Horton series (Lower Carboniferous). The areas of so-called Devonian encircle or partly surround still higher ridges of Pre-Cambrian strata.

Miles and Kilometres.

60·6 m. 97·5 km. **West Bay Road Station**—Alt. 214 ft. (65·2 m.). West Bay Road station is situated at the southern end of the Pre-Cambrian area of North Mountain. Beyond this station, as the railway descends to the crossing of River Inhabitants, the higher ground on the east is occupied by Millstone Grit. Where the railway crosses the river, the waters are practically at sea level. Beyond the river crossing the railway ascends the long slope on the southwestern side of the river valley underlain by the Limestone series and passes along the eastern side of two small lakes. About 1½ miles (2·4 km.) beyond the second of the two lakes the railway enters an area occupied by Millstone Grit and in part by strata belonging to the Coal Measures. From this point onwards the railway descends to Point Tupper on Canso strait. As the descent is made an extensive view is afforded of the upland country of the mainland across the straits. This upland area is chiefly underlain by strata mapped as Devonian and which are in part at least the equivalents of the Riversdale-Union series. A high, isolated hill known as Cape Porcupine rising on the western side of the straits, is occupied by Pre-Cambrian strata. As the railway nears the shore, rock cuttings in variously coloured shales and sandstones are common.

The Carboniferous area traversed by the railway from the River Inhabitants valley to Point Tupper includes a series of strata having a thickness of at least 19,000 feet (5,800 m.). The strata are traversed by strong faults and doubtless many minor faults are also present. The measures are usually inclined at rather high angles and apparently lie in open folds of large dimensions. Both on the west and east occur large areas of so-called Devonian. Sandstones and dark shale that have been correlated with the Horton series occur at the base of the measures that have been definitely assigned to the

Miles and Kilometres.

Carboniferous. Above these lie limestone and gypsum beds followed by a great thickness of shales and reddish and grey, plant-bearing sandstones. Above these lies a thick series of black shales with, in several places, coal seams. The highest strata presumably belong to the Coal Measures.

74·5 m. 120 km. **Point Tupper**—From Point Tupper the railway trains are ferried across Canso strait to the terminus of the railway on the mainland at Mulgrave. The strait at this point is 1,400 yards (1,280 m.) wide.

Along the shore on the Cape Breton side of the strait, the strata dip easterly at angles of 30° to 60°, and are well exposed over many partial sections to the north and south of Point Tupper.

From the Cape Breton side of the strait, the mainland is seen to rise quickly to a rolling upland. To the north however, the Pre-Cambrian area of Cape Porcupine forms a detached, higher mass. Nearly the whole length of the mainland side of the strait is bordered by so-called Devonian strata which extend from here in a continuous band westward to Windsor. These "Devonian" measures are of variously coloured shales and sandstones with an aggregate thickness of, presumably, considerably more than 5,000 feet (1,500 m.). The strata dip in various directions at angles usually of 45° or higher; they apparently are much folded. Plant-bearing beds occur at various horizons and, in a general way, the measures have been correlated with the Riversdale-Union group. At several places strata of the Horton series occur within this area in the neighborhood of Canso strait, and at several places along the shore, as just south of Mulgrave, there are limited areas of the Carboniferous Limestone series.

75·2 m. 121·1 km. **Mulgrave**—After leaving Mulgrave on the mainland side of Canso strait, the railway enters the valley bounding Cape Porcupine hill on the south and west. From this point may be seen the rolling ridges and low rounded summits of

Miles and Kilometres.

the Carboniferous area stretching inland from Point Tupper on Cape Breton island.

The railway passes close to the steep west face of Cape Porcupine hill which rises to an elevation of 640 feet (205 m.). This hill with a maximum diameter of 1½ miles (2·4 km.) is the only area of older Pre-Cambrian on the mainland of Nova Scotia. The rocks of the hill consist of quartzite, schists, "felsite," granite, etc. After passing to the west of Cape Porcupine, high hills and ridges on Cape Breton island are visible. These uplands lie in the Pre-Cambrian and "Devonian" area situated to the west of the Carboniferous area of the River Inhabitants basin.

After passing Cape Porcupine hill, the railway rises to a summit elevation of 398 feet (121·3 m.) and beyond this begins to drop to a lowland Carboniferous area that extends along the coast westward from the northern entrance of Canso strait. For about 3 miles (4·8 km.) westward, the railway continues through a somewhat broken country underlain by the "Devonian" strata. Beyond this the railway begins to descend somewhat rapidly and enters a district underlain by the Carboniferous Conglomerate series. This series consits of coarse red conglomerate and sandstone, purple slates, etc. Included in the area are dark shales, sandstones and thin limestones of the Horton series. The strata in a general way dip to the west away from the "Devonian" area and towards the coast, where, a few miles away, overlying beds of the Limestone series occur.

85·3 m.
137·3 km.

Harbour au Bouche Station—Alt. 271 ft. (82·6 m.). After passing Harbour au Bouche station, a view is afforded to the north of the hills of Pre-Cambrian rocks, in Cape Breton. To the west an extensive view opens up of the low-lying Carboniferous area bordering the sea as far as Antigonish, of the ranges of hills beyond Antigonish limiting the Carboniferous area in that direction, and of the upland of

Miles and Kilometres.

"Devonian" strata bounding the Carboniferous on the south.

Approaching Linwood, heavy cuttings in conglomerate, sandstone and shale occur along the railway. The rocks belong to the Conglomerate series and dip to the west at angles of 15° to 40°.

89·3 m. 143·7 km. **Linwood Station**—Alt. 127 ft. (38·7 m.). From the railway to the west of Linwood, the steep front of the ridges of "Devonian" may be plainly seen rising a short distance to the south. About 2½ miles (4 km.) beyond Linwood near the bridge over Black river, the railway line crosses the boundary between the Conglomerate series on the east and the Limestone series on the west. The Limestone series consists chiefly of sandstones and shales of various colours and kinds and in places bearing plant remains, and beds of limestone and gypsum. These measures, directly border the "Devonian" area on the south. The measures, in places over considerable areas, apparently lie in broad, open folds, in other districts the folding is closer and in certain areas the strata are contorted.

Less than 1 mile (1·6 km.) beyond the crossing of Black river, the railway approaches the shore of Tracadie harbour and continues to skirt it for a distance of several miles.

94 m. 151·3 km. **Tracadie Station.**—Alt. 48 ft. (14·6 m.). A short distance beyond Tracadie, the railway leaves the coast and for a number of miles runs through a low rolling country underlain by the Limestone series. The high lands to the west beyond Antigonish, continue in view throughout most of the distance. About 9 mile (14·5 km.) from Tracadie, the railway passes around the head of Pomquet harbour, an inlet of the sea about 3 miles (4·8 km.) long.

104·1 m. 167·5 km. **Pomquet Station.**—Alt. 43 ft. (13·1 m.). From Pomquet, the railway again strikes inland through the low Carboniferous area.

108·9 m. 175·2 km. **South River Station.**—Alt. 20 ft. (6·1 m.). A short distance beyond South River station, the railway approaches the shore of Antigonish

Miles and Kilometres.

harbour, an inlet of about 5 miles (8 km.) in length. The railway follows the shore of Antigonish harbour around a point and thence inland along the east side of the estuary of West river. Across the estuary on the northeast side, beyond a low interval occupied by the Limestone series, rise comparatively high hills of igneous material and Ordovician strata. Beyond these to the northward, the upland rises to altitudes of 600 feet (180 m.) and more, and is largely occupied by strata of the Carboniferous Conglomerate series. The upland area also extends inland and from the mouth of West river the hills to the west are distinctly visible. The railway runs inland along West river and in a short distance reaches Antigonish. The town is situated within but close to the northern border of the Limestone series which a mile to the north abuts against the hills of older strata.

114 m.
183·5 km. **Antigonish** —Alt. 20 ft. (6·1 m.).

ARISAIG.*

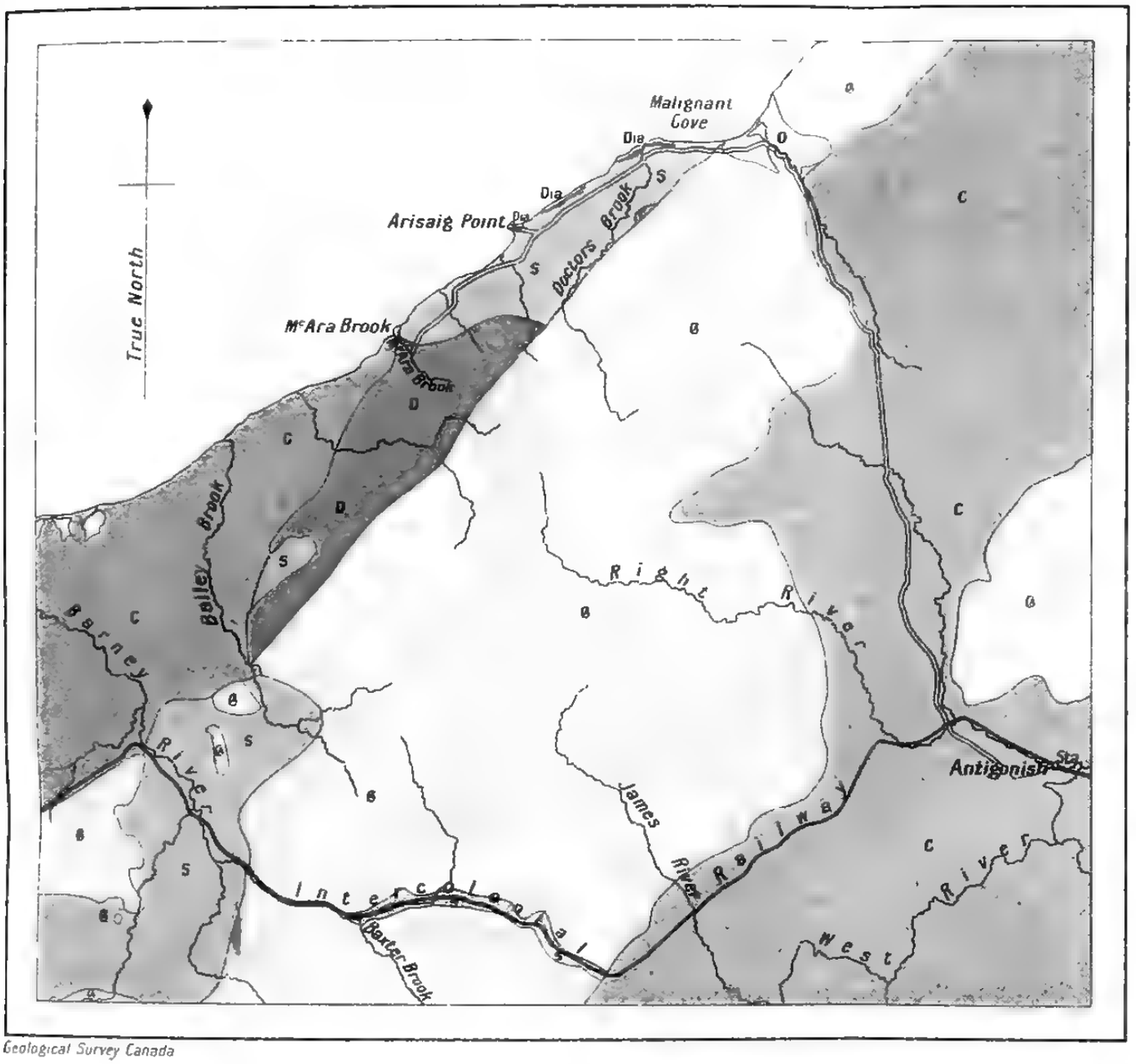
(W. H. Twenhofel.)

INTRODUCTION.

The Arisaig region consists of an upland built of old metamorphic and igneous rocks, having an average elevation of 800 to 1,000 feet (243 m. to 304 m.) and a lowland underlain by softer and younger sediments with an elevation of from 200 to 400 feet (60·9 to 121·9 m.). Nestling in the midst of the uplands are small lakes and wide marshes in which the brooks take their sources and, fed by never failing mountain springs, rarely cease their flow. The streams of the upland flow in deeply incised gorges and reach the lowland by a succession of falls and rapids, where they meander in gently graded valleys to the sea. On the top of the upland, the flat fields prove the former presence of an extensive, nearly level surface.

*See Maps—Arisaig—Antigonish District, and Arisaig.

Geological Survey, Canada



Geological Survey Canada

Arisaig-Antigonish District

Miles

1 0 2

Kilometres

1 0 2 4 6

Viewed from the sea, the lowland presents the appearance of three gigantic steps. The highest step at an elevation of about 140 feet (42 m.) is not well preserved; but the lowest two, at elevations of 20 (6 m.) and 40 feet (12 m.), are sharply defined. Each represents a wave cut beach.

For splendid exposures of Silurian rocks of great thickness there are few regions which surpass that of Arisaig. The shore cliffs are well developed and these with the sections exposed in the brook gorges show the Arisaig region to consist of large blocks, bounded by faults of great magnitude, so that a structural and formational map of the region forms an irregular mosaic. The fault of greatest displacement is that separating Eigg mountain from the narrower block of Silurian hills which fronts it. On the land the locus of the fault zone is plainly shown by the pronounced structural depression known as the Hollow which can be followed westward to Bailey's brook while its northeastward extension forms the straight coast reaching nearly to the end of the peninsula of Cape George. The downthrow of the Silurian block proved its preservation, but in its descent the drag along the fault zone produced an asymmetric synclinal trough, the rocks of which are criss-crossed by myriads of small faults and fractures.

PREVIOUS WORK.

The first student of the Arisaig sequence was J. W. Dawson, who investigated the region previous to 1845. He was succeeded by David Honeyman, who began his studies there about 1859. Following Honeyman came Fletcher, Faribault, Ami, Schuchert, Twenhofel, and Williams; each of whom has studied the section in whole or in part and in their published results have built up our present knowledge of the region. A compilation of their results is summarized in the following table of formations.

TABLE OF FORMATIONS.

System.	Formation.	Thickness.	Lithology.	Correlation, U. S.	Correlation, Europe.
		(Feet.)			
Pennsylvanian.	Listmore.....	982	Grey and brown sandstone and shale of continental origin.		
Mississippian.	Ardness.....	2,045	Varicolored shale and sandstone with locally some beds of gypsum and a basal limestone.	Kinderhook.	
	McAra's Brook...	1,145	Varicoloured shale and red sandstone and conglomerate with dykes and sheets of diabase.		
Lower Devonian.	Knoydart....	683+	Red sandy shale and grey sandstone with small dykes of diabase.	.....	Old Red Sandstone.
Silurian	Stonehouse ..	1,075	Red and grey limestone and shale.	Guelph.....	Ludlow.
	Moydart.....	379	The "Red Stratum" and grey limestone and shale.	Waldron and Louisville.	Upper Wenlock.

Silurian	McAdam....	1,120	Black and grey shale, grey limestone and 27 in. of hematite.	Rochester.....	Upper Wenlock. Upper Llandovery.
	Ross Brook..	833+	Green and black shale with interstratified thin sandstone.	Clinton.....	Lower Llandovery.
	Beech Hill Cove.	160+	Sandy limestone and shale underlain by a rhyolite flow into which have been intrusions of diabase.	Lowest Clinton.	
Ordovician?	Malignant Cove.	20+	Cross-bedded conglomerate with dykes of basalt.		
Ordovician?	Baxter's Brook.	500+	Red and grey sandstone and slate with intrusives of rhyolite, quartz porphyry, diabase and basalt.		
	James River.	5,280+	Flinty slate and grit with intrusives of granite, rhyolite, diabase, basalt, and monzonite.		

35063—6½A

Antigonish to McAra's brook.

The town of Antigonish (alt. 40 ft., 12 m.) is situated in the valley of Right river which follows what is apparently an ancient depression, now partially filled with the Carboniferous rocks of the McAra's Brook and Ardness formations, the latter of which immediately underlies the town. Less than a mile to the north of Antigonish the surface rises rapidly to the plateau, here underlain by the James River rocks, through which protrudes a core of diabase forming the elevation known as Sugar Loaf hill (alt. 760 ft., 213 m.). This portion of the plateau is separated from the larger area to the west by a lowland whose surface rocks belong to the McAra's Brook formation and through this lowland the Gulf road follows the valleys of Right river and Malignant brook to Malignant cove. Outcrops are not common. About two miles south of the Malignant cove shore the quartz porphyry of McNeil's mountain rises to the west of the road to an elevation of 1,010 feet (307 m.) while about a mile north the rhyolite hill of Sugar Loaf ascends to 680 feet (207 m.). At Malignant cove, a conglomerate, probably of Ordovician age forms the surface rock and may be seen at the Malignant Brook bridge crossing. For the first half mile west of Malignant cove the road is underlain by this conglomerate after which the Silurian forms the surface rock to McAra's brook.

McAra's brook and the shore section east to Arisaig point.

Just above the bridge crossing at McAra's brook are splendid exposures of the sandy shales from which Ami obtained his Old Red Sandstone (Knoydart) fossils. Below the bridge the hard red shales and grey sandstones are exposed in the bed and along the bank. A road along the west bank of the brook leads to its mouth, where the shore cliffs are formed either of the McAra's Brook conglomerate or the diabase intrusives by which it is cut. about a mile to the west the rocks of the Ardness formation form the cliffs, while the farthest headland visible from this point is in part built of the Pennsylvanian? conglomerates. McAra's brook reaches the sea by a gateway cut through a diabase dyke, on the seaward side of which

some blocks of the Mississippian conglomerate have been included in the diabase. By ascending the brook the Devonian shales as well as the Mississippian conglomerate and the amygdaloid which lies just above the base of the latter may be seen. For the first 250 yards (228 m.) east of McAra's brook the shore is formed almost wholly of amygdaloid. There is no beach and the top of the cliff must be followed. At McAra's boat landing, where descent can be made to the beach, the amygdaloid is succeeded by the McAra's Brook conglomerate which then forms the shore for about 125 yards (114 m.) where it is succeeded by the diabase dyke at the top of the Silurian. It is quite easy here to make a representative collection of fossils from the Silurian red limestones and shales. At the mouth of Stonehouse brook it is possible to obtain entire specimens of the trilobite, *Homalonotus dawsoni*.

From Stonehouse brook to beyond the "Red Stratum" there is no beach and this portion of the Silurian section must be studied from the top of the cliff. The "Red Stratum" and the overlying green shales are without fossils, but the limestone which underlies the former and forms the point to its east contains many specimens of a brachiopod resembling *Eatonia medialis*. Beyond this point is McDonald Brook cove wherein the Moydart rocks form low cliffs. The succeeding point is also formed of Moydart rocks, but in the cove to the east the formation comes to an end. At the western end of this cove descent can be made to the beach which, with few interruptions, extends to Arisaig point. The upper beds of the McAdam formation form a serrated cliff from which it is quite easy to collect many fossils, of which few are well preserved. The point east of McAdam Brook cove is formed of shales, which are full of pelecypod casts, and nearly unfossiliferous limestone. The eastern side of the succeeding cove does not offer good exposures, but from a few interstratified beds of limestone which project through the beach debris it is possible to collect large individuals of *Atrypa reticularis*. The slopes above this cove show the elevated terraces in a fine state of preservation. At its eastern horn is Black point, a headland formed of glacial gravels, on the eastern side of which the McAdam formation ends, being cut off by the fault which has elevated the Ross Brook shales and placed them on a level

with the basal McAdam limestones here forming a low anticlinal. At low tide the fault line is well shown, the shales on one side and the limestones on the other serving to make it very prominent, but at high tide it can not be seen. Beginning at the fault is the broad cove extending to Arisaig point. Its existence is determined by the readiness with which the Ross Brook shales yield to erosion. The upper half of the exposures is made prominent by the high cliffs of green shales, but in the lower half the cliffs are less high and steep. The lenticular beds of sandstone which are scattered through the shales make disconnected shelves across the cliffs and their varying thickness is excellently shown. In the green shales it is possible to collect fossils anywhere, but perfect specimens do not commonly occur. A good black shale fossil locality begins about 125 yards (114 m.) west of the mouth of Arisaig brook and extends to its east bank.

Arisaig point is formed of the upturned edge of the rhyolite flow at the base of the Silurian which, together with the amygdaloid by which it has been intruded, forms with a few interruptions, the shore for the next three miles.

The Beach Hill cove formation is so poorly exposed at Arisaig point that it is not possible to adequately examine it To see it in its completeness Beech Hill cove or Doctor's brook must be visited. The former locality is about three miles east of Arisaig point and is best reached by way of the shore road. There the beds are steeply upturned and form a sloping shore which at no place rises to a cliff. At Doctor's brook the beds of the Beech Hill cove formation form the cliffs below the shore road bridge and the same structural relations obtain as at Beach Hill cove.

DESCRIPTION OF THE GEOLOGICAL SEQUENCE.

The sequence of the strata in the Arisaig region begins in the Lower Ordovician and with many interruptions extends perhaps to the Pennsylvanian. Excepting the glacial and stream gravels there are no deposits later than the Pennsylvanian.

Ordovician, Brown's Mountain Group.

The oldest rocks of the region have been described as the Brown's Mountain group, a name proposed by Williams. On lithological grounds the group has been divided

into two formations, the lower and thicker of which is called the James River, and the upper, the Baxter's Brook. The strata lie in broad open folds on which have been superposed smaller secondary folds.

James River Formation.—The James River formation is described by Fletcher and Williams as consisting of clastic deposits of graywacke, silicified grits and banded slates into which have been intruded rocks of such varied character as granite, monzonite, rhyolite, quartz porphyry, diabase and basalt. The thickness according to Williams approximates one mile. Areally the rocks of this formation constitute the greater portion of the plateau and they contain most of "the beds" of iron ore which have been prospected here for many years. Some of the ore "beds" of the upper parts are similar to those of the Belle Isle oölitic deposits of Conception bay, Newfoundland, while other "beds" in the formation consist of grit impregnated with hematite. Williams inclines to the belief that the ores are of sedimentary origin. Their economic importance and extent are yet to be determined. From the iron ore and associated beds have been collected two species of inarticulate brachiopods, determined by Schuchert as *Obolus* (*Lingulobolus*) *spissa* and *Lingulella?*

Baxter's Brook Formation.—The James River rocks are succeeded on the northern portion of the plateau by the Baxter's Brook formation, consisting of metamorphosed red and grey sandstones and slates. Like the rocks of the preceding formation these have been cut by similar or the same intrusives with the exception of monzonite. The only fossils so far found are indeterminable *Linguloids*. Williams estimates the present thickness at 500 feet which is probably far less than the original.

Ordovician?

Malignant Cove Formation.—At Malignant Cove are exposed about 20 feet of coarse cross-bedded conglomerates and sands of varied color which rest unconformably on cleavage surfaces of the James River slates. These clastics contain material derived from all the preceding sedimentaries and intrusives except the diabase and basalt.

The deposits are probably not of marine origin, this conclusion being based on the absence of marine fossils and the poorly bedded and little sorted character of the sediments.

Silurian. Arisaig Series.

Where the base of the Silurian has been seen it rests on the eroded surface of a rhyolite flow extruded before the marine overlap of Arisaig time. The fault of the Hollow separates the Silurian from the Ordovician. On lithological grounds the strata can be placed in two subdivisions; the lower portion consisting almost entirely of shales, has a thickness exceeding 2000 feet (510 m.) while the upper shales and impure limestones are 1454 feet (373 m.) thick. The character of the sediments denotes proximity to the shore, a conclusion confirmed by the pronounced development of ripple marks, cross-lamination, and small lenses of sandy and impure limestone. On the basis of lithology and faunal differences the Arisaig series can be divided into five well marked formations to which, beginning at the base, the names of Beech Hill Cove, Ross Brook, McAdam, Moydart, and Stonehouse have been applied.

Beech Hill Cove formation.—This formation consists of greenish calcareous sandstones, sandy impure limestones and grey sandy shales. At the type section and at Doctor's brook the strata have an almost vertical attitude. The formation is poorly exposed at Arisaig point. Along the line of the Intercolonial railroad on Barney's river, opposite the mouth of Bear brook, and again at Marshy Hope, are outcrops of strata which probably belong to this formation. Fossils are nowhere abundant but the following have been recognized: *Zaphrentis* cf. *bilateralis*, *Lingula* cf. *oblonga*; *Dalmanella* cf. *elegantula*, and *Cornulites flexuosus*. The thickness has never been accurately determined. The present writer estimated the Beech Hill Cove outcrop at 160 feet (48 m.) while Williams gives the thickness as 200 feet (61 m.).

Ross Brook formation.—The strata of the Ross Brook are divisible into two divisions, a lower one (zone 1) of black papery shales with a thickness of about 200 feet (61 m.) from which no graptolites have been collected, and an upper division, 633 feet (193 m.) thick, throughout which graptolites are present in abundance. The upper division is again readily divisible into a lower subdivision

of dark grey to black shales (zone 2) with either splintery or papery cleavage and an upper one (zone 3) of more or less sandy bright green shales with which are interstratified numerous lenticular beds of compact, finely cross-laminated quartz sandstone. What appears to be the basal portion of the Ross Brook formation also outcrops on Barney's river opposite Avondale station on the Intercolonial railroad, where beds lithologically and faunally similar but without any graptolites form a cliff about 30 feet high on the north bank of the river.

The fossils which are characteristic of the formation are:

Monograptus clintonensis
M. priodon chapmanensis
Retiolites geinitzianus venosus
Orbiculoidea tenuilamellata
Dalmanella elegantula
Leptaena rhomboidalis
Plectambonites transversalis
Chonetes tenuistriatus
Camarotoechia near equiradiata
C. *cf.* obtusiplicata
Rhynchonella *cf.* robusta
Anoplotheca hemispherica
Anabaia anticostiana
A. depressa; and Calymene tuberculata.

Zone 1.—Black, rusty weathering papery shales which as a rule are little fossiliferous. The identified fossils are *Anoplotheca hemispherica; Anabaia anticostiana;* and *Lingula* cf. *oblongo;* The estimated thickness is 200 feet (61 m.).

Zone 2.—Dark-grey to black, rusty weathering shales with splintery or papery cleavage. In the shore cliffs the zone shows much disturbance and in some places the attitude changes with nearly every ten-foot interval. It is quite fossiliferous, particularly in graptolites, while pelecypods and brachiopods are comparatively common throughout and at a few levels are very abundant. The identified fossils are:—

Monograptus clintonensis
M. priodon chapmanensis
Retiolites geinitzianus venosus
Orbiculoidea tenuilamellata
Dalmanella elegantula
Chonetes tenuistriatus
Anoplotheca hemispherica

Anabaia anticostiana
A. depressa
Cornulites flexuosus
C. distans
Calymene tuberculata
Acaste downingiae
Dalmanites *sp.*

The thickness is 288 feet (87 m.).

Zone 3.—Green shales, in places sandy. Interbedded are numerous layers and lenses of fine-grained sandstones with fine cross-lamination. The strata are much disturbed in places, but the units of fracture are much larger than in the preceding zone so that there are few places where the bedding is confused. The zone ends at the top of the formation. The fossils which have been identified are:—

Monograptus clintonensis
M. priodon chapmanensis
Retiolites geinitzianus venosus
Orbiculoidea tenuilamellata
Dalmanella elegantula
Leptaena rhomboidalis
Chonetes tenuistriatus
Camarotoechia near equiradiata
C. cf. obtusiplicata
Rhynchonella cf. robusta
Wilsonia cf. saffordi
Anoplotheca hemispherica
Serpulites cf. dissolutus
Cornulites distans
Pterinea emacerata
P. rhomboidea
P. honeymani
Modiolopsis? cf. primigenis
Dalmanites, fragments of Eurypterus, and Conularia.

The thickness of the zone is 365 feet (110 m.)

McAdam formation.—The strata of this formation consist of papery and splintery shales, and argillaceous and sandy limestones. The attitude is more regular and uniform than in the preceding formation and there are fewer zones of marked disturbances. In the shore cliffs the lower portion is cut out by faulting, but the missing strata can be well seen in the gorge of Arisaig brook. The formation has been separated from the Ross Brook formation on both lithological and faunal grounds though

many species are common to both. The fossils which are especially characteristic are *Monograptus* cf. *riccartoensis. Dalmanella elegantula, Leptaena rhomboidalis, Camarotoechia neglecta, Atrypa reticularis, Spirifer crispus, Bucanella trilobata* and *Calymene tuberculata.* The McAdam formation has a thickness of 1120 feet (366 m.).

Zone 1.—The iron ore zone. Williams has described this zone as consisting of "firm shales and thin-bedded sandstones with 2 feet 3 inches of ferruginous shale and weathered hematite." The hematite is a "fossil ore" similar to the Clinton ore of the Appalachian region. The fossils are *Dalmanella elegantula, Leptaena rhomboidalis, Camarotoechia* near *neglecta, Homeospira* sp., *Meristina* near *oblata,* and *Cornulites flexuosus* or *proprius.* Since the fauna does not contain *Monograptus clintonensis* or *Anoplotheca hemispherica* and is more closely related to that which follows than that which precedes it has been referred to the McAdam formation. The thickness has been estimated by Williams at 100 feet (30 m.).

Zone 2.—Grey and greenish impure limestones interstratified with shale of the same color. The zone ends at the mouth of McAdam's brook. The identified fossils are:—*Pholidops implicata, Dalmanalla elegantula, D.* (a very large new species), *Leptaena rhomboidalis, Camarotoechia neglecta, C.* cf. *obtusiplicata, Atypra reticularis, Pterinea emacerata, Tentaculites* sp. and *Homalonotus dawsoni.*

The thickness is 540 feet (165 m.).

Zone 3..—Dark grey to black carbonaceous shale, the greater portion with papery bedding cleavage. At several levels are lenticular beds of fine-grained cross-laminated sandstone. The fossils are:—

Dalmanella elegantula
Laptaena rhomboidalis
Chonetes tenuistriatus
Camarotoechia neglecta
C. obtusiplicata
Atrypa reticularis
Spirifer crispus
Grammysia sp.
Cleidophorus sp.
Bucaniella trilobata
Calymene tuberculata.

About 75 feet (22 m.) from the top is a layer about one inch thick in which *Monograptus* cf. *riccartoensis* is present

in great abundance, while about 25 to 50 feet lower down there are many very large oblate spheroidal concretions. This zone has a thickness of 405 feet (123 m.).

Zone 4.—Grey and greenish grey impure limestones in thick layers all of which are steeply upturned with many of the beds beautifully ripple marked. Near the top they are much disturbed and in some places the bedding has been destroyed and the rocks reduced to breccia. *Dalmanella elegantula, Chonetes tenuistriatus* and *Cleidophorus* have been recognized. The estimated thickness of this zone is 70 feet (21 m.).

Moydart formation.—This formation introduces a change in lithology, the dark shales giving way to impure limestones and shales of some shade of grey. The change in facies is paralleled by a change in fauna. The formation ends on the top of the "Red Stratum."

The fauna is especially characterized by the appearance of *Chonetes novascoticus* and *Spirifer subsulcatus*, these two species taking the places of the earlier *Chonetes tenuistriatus* and *Spirifer crispus*. Other characteristic species are *Camarotoechia* cf. *formosa*, a rhynchonelloid resembling *Eatonia medialis, Homeospira* cf. *acadica, H.* cf. *evax, Pterinea emacerata, Grammysia* cf. *acadica, Diaphorostoma niagarensis*, and *Homalonotus dawsoni*. The thickness is 379 feet (115 m.).

Zone 1.—Greenish grey, impure limestone in beds up to four feet in thickness, interstratified with blue and grey sandy shales. As a rule fossils are not common, but in some limestone lenses they are present in great abundance. They consist of large crinoid columns, thick stems of a branching *Monticuliporoid, Dalmanella elegantula, Camarotoechia* cf. *formosa*, a rhynchonelloid resembling *Eatonia medialis, Spirifer subsulcatus, Homeospira* cf. *acadica, H.* cf. *evax, Pterinea emacerata, Grammysia acadica, Cornulites proprius, Serpulites* cf. *dissolutus, Orthoceras* (two species), *Diaphorostoma* cf. *niagarensis, Calymene tuberculata*, and *Homalonotus dawsoni*. The zone ends at the base of the "Red Stratum," and has a thickness of 347 feet (105 m.).

Zone 2.—The "Red Stratum," consists of a brick red shale of which the major portion has prismatic structure. Little stratification is shown except near the base where 27 inches of thin beds of red limestone and shale are transitional to the zone below. There is no transition to the overlying green shale. About 20 feet (6 m.) below the

top is a band composed of bright green nodules with their longer axes transverse to the bedding with a thickness of about 10 inches. Fracture lines which cut the "Red Stratum" are sharply defined by streaks of brilliant green. Except for some obscure forms in the transition beds at the base the zone is without fossils. The absence of well defined bedding and marine fossils suggests that the "Red Stratum" is not typically marine and that its deposition may have taken place during a brief recession of the sea. The thickness is 32 feet (9 m.).

Stonehouse formation.—This, the closing formation of the Arisaig series, is by far the most fossiliferous of the sequence. Lithologically the first 800 feet (243 m.) are not very different from the limestones of the Moydart formation, but faunally there is quite a distinction, the difference being largely in the abundance of large and undescribed pelecypoda. An unknown thickness of what appears to be the lower portion of the formation outcrops on the southwest end of a hill near the head of Vamey brook. The beds at this locality are flanked on both sides by the Devonian red shales and the structure appears to be anticlinal. The fauna is a large one and is characterized by the abundance and large size of *Chonetes novascoticus*, and an abundance of *Pholidops implicata*, *Spirifer rugaecosta*, *Homeospira* n. sp., *Grammysia acadica*, *G. rustica*, *Pterinitella venusta*, *P. curta*, *Calymene tuberculata*, *Acaste logani*, and fine large specimens of *Homalonotus dawsoni*,and in the last 200 feet (60 m.) by myriads of *Beyrichia pustulosa* and *B. aequilatera*. There is a total thickness of 1,075 feet (327 m.).

Zone 1.—Deep green unfossiliferous shales with a few lenticular bands of limestone. The zone rests in apparent conformity on the "Red Stratum", but the contact is obscure. The thickness is 33 feet (10 m.).

Zone 2.—Grey to green impure limestone in thick beds with a few beds of green and rusty purple shales and blue splintery flags. The limestones are criss-crossed by seams of quartz and calcite and the surfaces of many of the beds are highly ripple marked. The zone ends at the mouth of McPherson's brook. Fossils are not uncommon, but at no place are they abundant. They are *Strophеodonta* n. sp., *Leptaena rhomboidalis*, *Chonetes novascoticus*, *Atrypa reticularis*, *Spirifer subsulcatus*, *S. rugaecosta*, *Homeospira* cf. *evax*, *Grammysia acadica*, and *Pterinitella venusta*. The thickness is 532 feet (162 m.).

Zone 3.—Red and green shales, red and grey impure limestones, and grey splintery flags. The hard beds are veined by quartz and calcite and ripple marked as in the preceding zone. The zone ends at the mouth of Stonehouse brook and is very fossiliferous. The identified fossils are:—

Pholidops implicata
Chonetes novascoticus
Camarotoechia cf. nucula
C. cf. borealis
Spirifer rugaecosta
Homeospira n. sp.
Cornulites proprius
Beyrichia aequilatera
B. pustulosa
Acaste logani
Calymene tuberculata
Homalonotus dawsoni
Pterygotus fragments.

The zone has a thickness of 136 feet (41 m.).

Zone 4.—Red shales and limestones with greyish blue splintery flags. In the cliffs of the shore section this zone is spotted with very bright green patches. The base is drawn beneath the six inch layer of limestone forming the bed of Stonehouse Brook at its mouth and which contains an abundance of *Homalonotus dawsoni*. The zone is very fossiliferous. Those specifically known are:—

Pholidops implicata
Chonetes novascoticus
Schuchertella pecten
Camarotoechia cf. nucula
Spirifer rugaecosta
Homeospira n. sp.
Pterinitella venusta
Bucanella trilobata
Grammysia acadica
Goniophora transiens
Cornulites proprius
Beyrichia pustulosa
B. aequilatera
Calymene tuberculata
Acaste logani
Homalonotus dawsoni

The thickness is 97 feet (29 m.).

The section ends here, abutting against a dyke of diabase, the intrusion having flexed the beds, but little altered them. The dyke has a thickness of 40 to 50 feet (12 to 15 m.) and on its opposite side is in contact with the McAra's Brook conglomerate, the bedding of which is tilted in the same general direction as that of the Stonehouse formation, but there is no apparent alteration of the rock.

Devonian.

Knoydart formation.—The strata of this formation lie in the syncline formed by the Silurian rocks. An erosion unconformity separates the formation from the Silurian, since at McAra's brook it rests on the Stonehouse formation and in McAdam brook on the Moydart (Williams). It does not appear in the shore section, probably having been eroded before the deposition of the Mississippian conglomerates. The strata consist of hard red shales interbedded with compact fine-grained grey sandstones. Above the bridge over McAra's brook are sandy shales which were formerly considered to be of tuffaceous origin and have been referred to in the literature as the "ash bed," but the work of Williams has thrown doubt on this view. Several diabase dykes occur in the lower portion and in the higher rocks of the formation there are numerous small geodes lined with clear crystals of quartz. The available evidence indicates a continental origin for the Devonian sediments and it is very probable that they are the deposits of some Devonian river. From the "ash bed" Ami collected fossils which were identified by A. Smith Woodward and Henry Woodward as *Pterygotus* sp., *Onchus murchisoni*, *Pteraspis* cf. *crouchii*, *Psammosteus* cf. *anglicus*, *Cephalaspis* n. sp., and *Ichthyordichnites acadiensis*, the last being impressions made by a supposed animal having sharp pointed spines or similar organs. Fletcher (1887) gives the thickness of measured outcrops as 636 feet (193 m.).

Mississippian.

McAra's Brook formation (Williams).—This formation begins with a red cross-bedded conglomerate composed of angular fragments of the older rocks, in particular some of the quartz geodes from the Devonian. Above

the basal conglomerates are beds of limy grey and green shales and other conglomerates. Many intrusive bodies, in the form of dykes and sheets, cut the formation. At Pleasant valley and in the vicinity of Maryvale in the Big Marsh, the upper portion contains beds of oil shale (Ells, 1908), which with associated beds have a thickness of 125 feet (38 m.). Plant fragments are present in these shales, but in the shore sections no organic remains have been found. There is hardly any doubt that the deposits are of continental origin and were laid down in the old erosion channels. Fletcher gives the thickness as 1145 feet (346 m.).

Ardness formation.—This formation begins with about 20 feet (6 m.) of limestone, thin-bedded at the summit and base, but compact near the centre. The remaining more than 2000 feet (610 m.) consist of sandstone, shale and marl. The prevailing color is red and the sandstones are ripple marked. Along the line of the Intercolonial railroad near Antigonish the bed of limestone is overlain by about 200 feet (60 m.) of red sandstone and shale which are followed by about an equal thickness of gypsum. The bed of limestone is certainly of marine origin while the gypsum was probably deposited in arms of the sea having slight connection with the parent body. In the shore section there is no evidence for considering the beds above the limestones of other than continental origin. From the limestones Williams obtained fossils which Schuchert identified as *Beecheria davidsoni* (*Terebratula sacculus* Davidson), *Martinia glabra*, *Pugnax* sp., *Productus* cf. *doubleti*, and *P. dawsoni*. The thickness of the formation is 2045 feet (622 m.) (Williams).

Pennsylvanian.

Listmore formation.—The name Listmore has been proposed by Williams for a series of sandstones and shales, generally of red color which lie in apparent conformity on the Ardness formation. The deposits are of continental origin and contain imperfect specimens of *Stigmaria* and *Calamites* as the only organic remains. The thickness is 982 feet (299m.).

With this formation the sedimentary record closes and there were no other deposits laid down in the Arisaig region till the advent of the ice sheets when irregular masses of

sand and gravel were spread over some portions of the surface. Recent deposits consist of the stream gravels and soils.

Igneous Geology.— In the Arisaig region in the interval between the Lower Ordovician and Silurian and again during the Mississippian period there were intrusions of varied rock types. The Lower Ordovician rocks at some time subsequent to the deposition of the James River beds, but apparently before the laying down of the Malignant Cove conglomerate were intruded by quite large masses of granite and monzonite. Where fresh the granite is of a bright, flesh-red colour, very compact, tough and fine-grained and contains feldspar and quartz in the ratio of about 2 to 1. The areas of outcrop are south of Malignant cove and the intrusion appears to be in the form of a stock. The time of the intrusion was certainly subsequent to James River deposition and perhaps also Baxter's Brook, but prior to Malignant Cove time, since in thin sections of the last, Williams has found particles derived from the granites.

The monzonite outcrops on the shore about one half mile east of Malignant Cove. The intrusion appears to be in the form of a stock and consists of a medium granular rock in which white plagioclase feldspar and green hornblende are the chief constituents. The colour is a mottled green and white. Fragments of this rock are in the Malignant Cove conglomerate so that the time of the intrusion is probably to be placed in the same interval as the granite intrusives.

At the base of the Silurian section are splendid exposures of the upturned and eroded edges of a devitrified rhyolite flow. In places this passes into a flow breccia and at Frenchman's Barn, a large knob of rhyolite about a mile east of Arisaig village, there are considerable masses of breccia which may be the result of explosive action, but which Williams also considers flow breccias. Historically the rhyolite is of interest since it was considered by the earlier workers as having been produced by the metamorphism of sediments and *Eozoon* was reported from some portions of it. Cutting the rhyolite are large dykes of amygdaloidal diabase and a dyke of red shaly rock which cuts both rhyolite and diabase. In places the rhyolite shows flow structure and the color varies from grey

to green and black. The time of the extrusion was pre-Arisaig and since fragments of a similar rock occur in the Malignant Cove conglomerates it is probable that it was antecedent to the deposition of that formation.

Elsewhere in the Arisaig district are outcrops of rocks which Williams has called acid intrusives, consisting of dark colored rhyolite and quartz porphyry, the outcrops finding their greatest physiographic expression at Sugar Loaf hill (rhyolite) south of Malignant Cove and McNeil's mountain (quartz porphyry), just south of the Sugar Loaf hill and one of the highest points of the area. Associated at one or two localities are rhyolite flow breccias. The intrusions are in the form of dykes and larger masses which Williams has described as necks and cut either the James River and Baxters' Brook sediments or the James River granites. The available evidence points to their formation during the same phase of volcanic activity in which the rhyolite outflow at the base of the Silurian occurred. Also in the Malignant Cove—Sugar Loaf area are tuffs and breccias which are apparently interbedded and contemporaneous with the James River slates.

In the shore cliffs there are no rocks more conspicuous than the black dykes of amygdaloidal diabase or basalt. These cut all the strata except those of the Ardness and Listmore formations and are themselves cut by the red dyke. The intrusions are in the form of dykes and sheets and some may be flows. The largest observed intrusion begins at Arisaig pier and extends eastward for about three miles, but most of them do not have a width exceeding 100 feet (30 m.). The intrusions are all of one age as no diabase was seen to cut diabase. The fact that neither the Ardness nor the Listmore formations are cut by these dykes suggests that the time of the intrusions was pre-Ardness but it does not necessarily follow that this view is correct as there may not have been intrusions in the localities of the present outcrop of these rocks. The red dyke resembles a shale and on the basis of unpublished chemical analyses was considered such by the writer, but after more extended study, Williams is inclined to regard it as an intrusion. It cuts the diabase and may have been intruded during a later phase of that period of igneous activity.

Lower Ordovician.—*Obolus* (*Lingulobolus*) *spissa* from the upper James River slates also occurs in or associated with the oölitic iron ores of the Lower Ordovician of Belle Isle, Conception bay, Newfoundland. The occurrence of the same species with similar deposits at Arisaig leads to the correlation of the Arisaig measures with the Belle Isle rocks. The close stratigraphical relations of the Baxter's Brook beds with those of the James River hardly permits their separation and they are included therewith and considered part of the same system.

Ordovician?—The Malignant Cove formation contains no fossils so that its age determination depends on superposition. Since it is separated from the Lower Ordovician rocks by both an erosional and structural unconformity and appears to lie below the Silurian, it has been referred to the Ordovician (Williams).

Silurian.—The rocks of the Arisaig series are abundantly fossiliferous, but careful and painstaking collecting is required. Free fossils are not common. The number of species was given by Ami in 1891 as 162, of which about 100 have been described; but it is safe to say that the collections now in the various museums, particularly those of the Canadian Geological Survey, the U. S. National Museum, and Yale, will largely increase the above number.

The Silurian faunas taken as a whole predominate in pelecypods, as fully one-third of the species and specimens belong to this class of invertebrates. Brachiopods, generally the most abundant of Silurian fossils, at Arisaig hold second place, which place is attained by reason of the occasional deposition of lenses of relatively pure limestone and not because they are abundant in the sediments as a whole. Cephalopods and gastropods are about equally represented, though neither group has more than half a dozen species. Bryozoa and corals, usually so abundant in strata of this age, are almost wholly absent, the former being present in but a few stems of a ramose *Monticuliporoid*, while of the latter only a few specimens of a single species have been collected. Trilobites are relatively abundant. These faunal peculiarities with but little doubt are caused by the muddy character

of the habitat, which was extremely unfavourable to the corals, crinoids, bryozoa and many brachiopods, but apparently favourable to the pelecypods and not harmful to the trilobites.

The Silurian fossils of Arisaig in aspect are more European than American, but yet are unlike those of either country. Other than such cosmopolitan species as *Dalmanella elegantula*, *Leptaena rhomboidalis*, *Camarotoechia neglecta*, *Anoplotheca hemispherica*, and *Atrypa reticularis*, there is little else in the faunas that occurs elsewhere.

By reason of its nearness, the Anticosti faunas apparently should show close relations with those of Arisaig and although separated by less than 250 miles (400 km.), the two regions have less than ten species in common. The only portion of the Anticosti series with which a stratigraphic correlation can be definitely made is the lower Jupiter River formation in which are found *Monograptus clintonensis*, *Dalmanella elegantula*, *Plectambonites transversalis*, *Leptaena rhomboidalis*, *Anoplotheca hemispherica*, and *Calymene tuberculata*, all of which species are also present in the upper 633 feet (193 m.) of the Ross Brook formation. The Jupiter River sediments which contain these species are 80 feet (24 m.) thick and consist of highly calcareous shales which are succeeded by deposits containing a greater lime content and preceded by a 100 foot zone of slightly sandy shale underlain by sediments rich in lime. At Arisaig *Atrypa reticularis* appears for the first time in the second zone of the McAdam formation, but on Anticosti it makes its appearance below the *Monograptus clintonensis* horizon. Its later appearance at Arisaig may be due to the great amount of mud in the Ross Brook sea. The 80 feet of the Jupiter River rocks are the time equivalents of at least a part and perhaps the whole of the 633 feet of the Ross Brook formation, since it is very probable that the latter were accumulated far more rapidly than the former.

The succeeding Jupiter River rocks would correlate with the lower McAdam formation, but there is no similarity in either the lithology or the faunas. The Chicotte, the closing formation of the Anticosti series, carries a pronounced coral fauna and its rock consists largely of coral-reef limestone. Nothing similar exists in the McAdam formation, from which not a single coral has ever been collected. It is believed that the striking faunal

differences between Anticosti and Arisaig are to be referred to differences in the bionomic conditions existing at the time of deposition of the sediments.

Correlation with the Silurian of the interior is equally difficult. As before, the Ross brook faunas furnish the point of departure because the same fossils which have been mentioned above as occurring on Anticosti are also present in the Clinton of New York where also beds of hematite occur which, however, lie below the strata containing Monograptus instead of above as at Arisaig. The only New York formation which can be correlated with an Arisaig horizon is the Williamson shale with *Monograptus clintonensis* and *Anoplotheca hemispherica*. The presence of these two fossils in the Williamson shale leads to the conclusion that it is the time equivalent of the upper half of the Ross Brook formation. On this view the preceding Sodus green shale, the Furnaceville hematite bed, and the Wolcott limestone would find their time equivalency in the basal portion of the Ross Brook formation and the sandy limestones of the Beech Hill Cove formation. The common Clinton guide fossil, *Pentamerus oblongus*, which is so abundant in New York has not been found at Arisaig.

The Rochester, which succeeds the Clinton of New York, is thought to find its equivalency in the McAdam formation with which it has in common the species *Monograptus riccartoensis*, *Dalmanella elegantula*, *Leptaena rhomboidalis*, *Camarotoechia neglecta*, *C.* cf. *obtusiplicata*, *Atrypa reticularis*, *Spirifer crispus*, *Pterinea emacerata*, *Bucanella trilobata* and *Calymene tuberculata* or *niagarensis*. The Moydart formation has generally been considered the time equivalent of the Niagaran and in its faunal development it agrees best with the Waldron and Louisville of the United States. However, these formations have few fossils in common.

The Stonehouse formation has been variously correlated. Ami and Fletcher considered it as representing the Lower Helderberg, but it is difficult to see any Helderbergian affinities in this fauna. On a basis of its stratigraphic position the formation agrees best with the Guelph, but the two faunas are wholly different. On the other hand the Stonehouse faunas appear to be similar to those of the north European Ludlow, the equivalent of which in Gotland has, according to Lindstrom, Moberg, and others, the common Guelph fossil, *Megalomus*.

Correlation with the European faunas are not readily made, and until the Arisaig faunas have been completely studied there would appear to be little value in making the attempt in any great detail.

The presence in the Ross Brook fauna of *Dalmenella elegantula*, *Leptaena rhomboidalis*, *Plectambonites transversalis*, and *Anoplotheca hemispherica* indicates for this and the Beach Hill Cove formation a probable time equivalency with the Lower Llandovery of north Europe.

The highest beds of the McAdam formation contain *Monograptus riccartoensis* and *Spirifer crispus*, both of which are characteristic of the north European Middle Wenlock, and their common presence would lead to the reference of the highest beds of the formation to Middle Wenlock time while the great body of the formation should probably be placed in the Upper Llandovery. Other fossils common to the Upper Llandovery and the McAdam formation are *Dalmanella elegantula*, *Leptaena rhomboidalis*, *Atrypa reticularis* and *Calymene tuberculata*, all of which, however, also occur in the Wenlock.

The Moydart formation is marked by the earliest appearance of *Chonetes novascoticus*, which suggests, but is smaller than the European *C. striatella; Wilsonia wilsoni* (Ludlow of Norway, Wenlock and Ludlow of England); and *Spirifer subsulcatus*, a form of the *S. crispus* type but larger. *Calymene tuberculata* and *Leptaena rhomboidalis* are also present. The fauna is one suggesting an approach to the Ludlow, but still within the Wenlock.

The abundance of large *Chonetes* of the *C. striatella* type, *Rhynchonella nucula*, and *Schuchertella pecten* indicate for the Stonehouse formation an horizon equivalent to the north European Ludlow.

Devonian.—The Knoydart formation contains the remains of ostracoderm fishes whose closest generic relationships, as stated by Woodward, are with those occurring in the Old Red Sandstone of Europe. This indicates a lower Devonian age for the Knoydart strata. Their age can be determined, although less definitely, by another line of reasoning. The period of faulting in which the great fault of the Hollow was formed, is post-Knoydart and pre-Mississippian, since the rocks of the former are involved and those of the latter cross the fault. To the northwest before the close of Devonian time occurred disturbances which are expressed in the folds and faults

of the Gaspe region, and it is very possible that these are related in time and cause to the pre-Mississippian disturbance of the Arisaig region. Hence the time of deposition of the Knoydart clastics was previous to later Devonian time.

Mississippian.—The fossils from the limestone at the base of the Ardness formation are also present in the Windsor dolomites at Windsor, Nova Scotia, and in rocks of the same age on the Magdalen islands, thus leading to the reference of the Ardness formation to the Windsor series which, according to Schuchert* and Beede†, is the equivalent of the Kinderhook of the Mississippi valley.

Pennsylvanian?—The Listmore rocks are difficult to place. Fletcher correlated them with the Millstone Grit which underlies the Coal Measures and is of Pennsylvanian age. The plant remains are uncertain and obscure and any correlation based on them would have but little value.

BIBLIOGRAPHY.

Reference is here made to only a few of the more important papers dealing with the Arisaig region. For a complete bibliography relating to the Silurian the paper by Twenhofel should be consulted as well as a forthcoming report of the Canadian Geological Survey by Williams.

1860. J. W. Daswon, on the Silurian and Devonian rocks of Nova Scotia, Can. Nat. Geol., vol. V, pp. 132–143.

1860. James Hall, Silurian Fossils of Nova Scotia, Ibidem, pp. 144–159.

1864. D. Honeyman, on the Geology of Arisaig, Nova Scotia, Quar. Jour. Geol. Soc. London, vol. XX, pp. 333–345.

1874. E. Billings, Paleozoic Fossils, vol. II, pt. I. pp. 129–144.

1887. Hugh Fletcher, Report on geological surveys and explorations in the counties of Guysborough, Antigonish and Pictou, Nova Scotia, Ann. Rept. Geol. Surv. Canada, vol. II, pp. 5P–128P.

1891. J. W. Dawson, Acadian Geology, 4th edition, London.

*Schuchert, Geo. Soc. Am. Bull. 21, p. 551, 1910.
†Beede, New York State Museum. Bull. 149, p. 158.

1892. H. M. Ami, Catalogue of the Silurian Fossils from Arisaig, Nova Scotia, Nova Scotian Inst. Nat. Sci., n. ser., vol. II, pp. 185–192.

1909. W. H. Twenhofel, The Silurian Section at Arisaig, Nova Scotia, with a note on Correlation by Charles Schuchert, Am. Jour. Sci. 4th ser., vol. XXVIII, pp. 143–169.

1912. M. Y. Williams, Geology of Arisaig-Antigonish District, Nova Scotia, Am. Jour. Sci., 4th. ser., vol. XXXIV, pp. 244–250.

ANNOTATED GUIDE.

Antigonish to Maccan junction.

(G. A. Young.)

Miles and Kilometres.

0 m.
0 km. **Antigonish**—Alt. 20 ft. (6 m.). From Antigonish westward, the Intercolonial railway for some miles follows the northern edge of a low-lying area occupied by strata of the Carboniferous Limestone series (Windsor series?), close to the bordering upland of older strata that stretches northward to the coast. For a short distance the railway lies on the north side of Rights river along which white cliffs of gypsum are visible, the strata dipping to the south at an angle of 40°. A short distance to the northeast rise high hills of deformed strata presumably of Ordovician age and intruded by basic igneous masses. At a distance of $1\frac{1}{2}$ miles (2·4 km.) from Antigonish, the railway crosses Rights river and for a very short interval, enters an area occupied by the Carboniferous Conglomerate series; tilted, red sandstones and conglomerates of this series are exposed along the river. The strata of the Conglomerate series occupy an area several miles wide that extends northwards along a depressed area across the upland. To the eastward the strata of the Limestone series abut directly against the bounding Ordovician, but to the westward a narrow band of the Conglomerate series is interposed.

Miles and Kilometres.

About $\frac{1}{4}$ mile (0·4 km.) beyond the first crossing of Rights river, the railway again crosses the river and shortly re-enters the area of the Limestone series. The railway follows the river closely and along it occur cliffs of gypsum. The southern boundary of the Conglomerate series lies just north of the railway. The strata of this series dip in a general southerly direction at angles varying from quite low to as high as 70°. One mile (1·6 km.) beyond the second crossing of Rights river, the railway crosses it again where it issues from the higher ground to the north.

Beyond the third crossing of Rights river the railway passes along the sides of a series of small streams, the alternate ones flowing respectively east and west. Along the streams occur low cliffs of gypsum, while in places between the heads of streams the presence of gypsum is indicated by the characteristic "sinks". The Limestone series, as developed along the line of the railway, consists of a basal limestone member possibly about 10 feet (3 m.) thick overlain by about 200 feet (60 m.) of red sandstone and shale, above which lie about 200 feet (60 m.) of gypsum. The basal limestone rests on greenish conglomerate of the Conglomerate series which west of a point about $1\frac{1}{2}$ miles (2·4 km.) west of the third crossing of Rights river, is confined to a narrow zone bordering the steep front of the upland which rises a short distance north of the railway.

The steeply rising hills are underlain by closely folded greywacke varying to an impure quartzite and interbedded with a very siliceous slate. These measures compose the James River formation which is possibly 5,000 feet (1,500 m.) thick and is presumed to be of Ordovician age. The strata are penetrated by irregular intrusions of diabase and rhyolite and by one mass of granite underlying an area of several square miles.

About 8 miles (12·9 km.) from Antigonish the railway crosses James river, a southward flowing stream which issues from the hills through a deep, V-shaped valley. At the crossing of

Miles and Kilometres.

James river an extensive view is afforded to the south across the low-lying area of the Limestone series to the southern uplands of "Devonian" and older strata.

9·4 m. 15·1 km. **James River Station**—Alt. 203 feet (61·9 m.). The front of the uplands bordering the low area of the Limestone series on the north, strikes about southwest and a short distance beyond James river the railway enters the abruptly rising upland area by way of the deepset valley of Hartshorne brook. This valley and its continuation to the west, is underlain by Silurian strata forming a narrow strip rarely wider than $\frac{1}{4}$ mile (0·4 km.) bounded on both sides by a high, plateau-like upland occupied by Ordovician strata belonging in part to the James River formation and in part to the younger Baxter Brook formation which consists of reddish and greenish slates, and sandstones and conglomerates. The Silurian measures in places are fossiliferous and include shales, sandstones and limestones.

About $2\frac{1}{2}$ miles (4 km.) from the entrance to Hartshorne brook valley, the head of the valley is reached and the railway crosses a low summit (altitude, 451 feet or 137·5 m.) separating Hartshorne valley from another valley drained by a small stream flowing westward to Barney river. Hartshorne brook as far as its head, occupies a pronounced, though narrow, deep-set valley. At the summit and on the divide, the valley contracts; to the west of the summit, the valley quickly widens, though still narrow, and is occupied by a small westerly-flowing brook whose volume is altogether disproportionate to the depth of the valley.

13·3 m. 21·4 km. **Marshy Hope Station**—Alt. 373 ft. (121·9 m.). At Marshy Hope station, the east branch of Barney river, flowing from the north, enters the valley traversed by the railway, at a point about 1 mile (1·6 km.) west of the summit. The tributary valley of the east branch of Barney river is very narrow and steep walled whereas the main valley through also narrow,

Miles and Kilometres.

is comparatively broad and its slope less steeply inclined.

Below Marshy Hope station the valley, for a distance of 1½ miles (2·4 km.) continues to be underlain by Silurian strata everywhere confined to a narrow strip seldom more than 400 yards (365 m.) wide. Beyond this point the valley floor as well as the uplands, are occupied by the Ordovician strata. About 2 miles (3·2 km.) farther, the valley followed by the railway joins the broad valley of the main branch of Barney river.

17·2 m. 27·3 km. **Barney River Station**—Alt. 183 ft. (55·8 m.). Barney River station is situated on the west side of the comparatively wide valley of Barney river. This valley is underlain by folded and faulted Silurian measures occupying a low area about 2 miles (3·2 km.) broad bounded by steep slopes of Ordovician and igneous rocks. The Silurian area extends several miles to the south and then bends to the west. It extends about the same distance to the north to where the Silurian strata are overlapped by Carboniferous measures. The low-lying Silurian area is traversed by several streams which unite to form the northward flowing Barney river.

18·1 m. 29·1 km. **Dewar Station**—Alt. 160 ft. (48·8 m.). Dewar station is situated at about the centre of the Silurian area at the confluence of the two main branches of Barney river.

19·2 m. 30·9 km. **Avondale Station**—Alt. 151 ft. (46 m.). Avondale station is on the western side of the Silurian area close to the boundary with the Ordovician. About ½ mile (0·8 km.) beyond Avondale station, the railway enters an area of Carboniferous strata extending to the sea coast, and turning through an angle of 90°, proceeds westerly near the northern foot of the upland area crossed by the railway and which separates the low-lying Carboniferous area on the north that extends westward to the Pictou coal field and beyond, from the equally low-lying area of the Antigonish Carboniferous

Miles and Kilometres.

area. The steep northern face of the upland extends along a fairly uniform northeast-southwest course. To the northeast the upland finally approaches the sea coast. In this direction, in the Arisaig district, the northern face of the upland marks a profound fault, presumably this is true also to the southwest. The upland in its extension both to the northeast and southwest is mainly underlain by Ordovician strata with large areas of igneous rocks. In places also, Silurian measures are largely developed.

Where the railway, a short distance beyond Avondale station, enters the Carboniferous area, the strata belong to the Limestone series and consist chiefly of grey and red sandstones with, towards the base, several beds of limestone. These measures, with low northeasterly dips, form a zone several miles wide extending in a northeasterly direction and in the immediate district rest directly on the Silurian strata. On the sea coast these rocks have a thickness of about 2,000 feet (600 m.) and on fossiliferous evidence have been correlated with the Windsor series.

At a distance of about $1\frac{1}{2}$ miles (2·4 km.) from Avondale station, as the railway follows along the southern boundary of the Carboniferous at the foot of the upland of Ordovician, it leaves the area of the Limestone series and enters a district occupied by Millstone Grit which at the south boundary rests directly on the Pre-Carboniferous strata. The railway in this part of its course, ascends a valley, crosses a divide (altitude, 288 feet or 87·8 m.) and enters the valley of Huggan brook. From the neighborhood of the summit, a view to the northeast shows the sharply marked, nearly straight front of the upland of older strata and the low, rolling Carboniferous area extending from its foot to the sea.

23 m.
37 km. **Piedmont Station**—Alt. 241 ft. (73·5 m.). The Millstone Grit strata in the neighborhood of Piedmont station consist of grey and reddish shaly sandstones with coal-like matter; the

Miles and Kilometres.

basal member is composed of conglomerates reposing directly on the Ordovician strata forming the face of the upland. The Carboniferous measures dip to the northward, towards the sea at angles of 10° to 30°.

After leaving Piedmont station, the railway for a distance of about 1 mile (1·6 km.) continues to parallel the north face of the upland but beyond this point, the railway bends and runs towards the coast through a low broken country underlain by the Millstone Grit. A view of the sea is afforded at Merigomish.

27·8 m. 44·7 km. **Merigomish Station**—Alt. 18 ft. (5·5 m.). A short distance west of Merigomish station the railway crosses French river. Numerous exposures of Millstone Grit beds occur along the river. The strata consist largely of red and grey or greenish sandstones and shales with a few very thin coal seams and occasional thin beds of argillaceous limestone. The strata dip in a general way towards the north or west, and are traversed by a series of faults trending east and west.

From Merigonish the railway runs in a southwestward direction parallel to but about a mile distant from the shore of Merigomish harbour.

31·2 m. 50·2 km. **West Merigomish**—Alt. 77 ft. (23·5 m.). The Millstone Grit strata extend westward past West Merigomish to the border of the area of Productive Coal Measures of the Pictou coal field.

Beyond West Merigomish station, the railway swings around the head of Merigomish harbour and from the railway a good view is obtainable of the low islands and irregular shores of this indentation of the sea. About 3 miles (4·8 km.) beyond West Merigomish the railway crosses the mouth of Pinetree brook. One-half mile (0·8 km.) farther, the railway enters an area occupied by the New Glasgow Conglomerate which forms a ridge extending westward to New Glasgow. These measures consist of red conglomerates with lenticular beds of sandstone;

Miles and Kilometres.

they dip to the north at angles of 15° to 30°, and occupy a band having a breadth of somewhat more than ½ mile (0·8 km.). Along their south boundary the strata have been described as unconformably overlying Millstone Grit; along their northern boundary they are conformably succeeded by sandy shales forming a very thick series displayed over a large area for many miles to the west. By Fletcher, the New Glasgow Conglomerate was considered to mark the base of the so-called Permo-Carboniferous or Permian series.

As the railway ascends the ridge underlain by the New Glasgow Conglomerate, a view opens up across the head of Merigomish harbour and the low, rolling Millstone Grit country beyond, to the high abruptly rising upland of pre-Carboniferous strata already traversed by the railway. The railway crosses nearly the whole width of the band of New Glasgow Conglomerate but before reaching the northern boundary, turns to the westward and for some distance runs parallel with it.

35·6 m.
57·3 km.

Woodburn Station—Alt. 136 ft. (41·4 m.). From Woodburn station, for a distance of about 1 mile (1·6 km.) the railway continues within the area of the New Glasgow Conglomerate. Beyond this it enters the "Permo-Carboniferous" area.

Some distance farther, the railway crosses a low divide (altitude 218 feet or 66·4 m.) and enters the valley of Smelt brook. From the summit, the country to the north may be seen to be low and gently rolling. As the railway descends the valley of Smelt brook, occasional outcrops of grey "Permo-Carboniferous" sandstone are visible. Before reaching the mouth of Smelt brook, the railway turns to the south, follows up the east side of East river, and recrosses the belt of New Glasgow Conglomerate exposed along the banks of the river within the limits of the town of New Glasgow. The railway station is situated a very short distance south of the

Miles and Kilometres.

conglomerate band, within the area of the Productive Coal Measures of the Pictou field.

41·5 m. 66·8 km. **New Glasgow**—Alt. 29 ft. (8·8 m.). The railway route between New Glasgow and Truro is described on pages 222 to 229.

84·4 m. 135·8 km. **Truro**—Alt. 60 ft. (18·3 m.). From Truro the Intercolonial railway runs westerly through the Triassic area extending along the north side of the Bay of Minas. The country underlain by the Triassic is low and rises very gradually from the shore of the Bay of Minas. The northern boundary of this area lies at a variable distance, in most places between 1 and 2 miles (1·6 km. and 3·2 m.), north of the railway and is marked by the abruptly rising front of an upland which merges farther inland, into the Cobequid hills.

The hilly district bordering the Triassic area on the north is in part underlain by measures of the Riversdale-Union group lying with steep angles of dip in a series of east-west folds. The Triassic strata are mainly red conglomerates and sandstones, which are in general, horizontal or dip at low angles except along the northern border where the strata are usually inclined at angles of 30° to 45°.

91·9 m. 147·9 km. **Belmont Station**——Alt. 84 ft. (25·6 m.).

97·8 m. 157·4 km. **East Minas Station**—Alt. 193 ft. (58·8 m.). In this district the Triassic area extends inland for from 5 to 6 miles (8 to 9·6 km.). To the westward, the band of Triassic strata continues for many miles along the coast of the Bay of Minas and in places the sediments are associated with diabase or basalt. The igneous rock in general occurs in large sheet-like bodies overlying the sediments; in some cases, at least, the masses are dyke-like or are sills.

At East Minas station, the northern boundary of the Triassic sediments lies about 1 mile (1·6 km.) north of the railway and there the Triassic is in contact with strata mapped as Carboniferous Conglomerate (lowest Carboniferous) by Fletcher. This area of the "Car-

Miles and Kilometres.

boniferous Conglomerate" extends for many miles both to the east and west, in the form of a band varying in width between 1 and 2 miles (1·6 km. and 3·2 km.). Along the northern edge of this band of "Carboniferous Conglomerate" occur so-called Devonian strata of the Riversdale-Union group, and from a point not far east of East Minas station, the same "Devonian" beds lie along the southern boundary of the Conglomerate series between it and the Triassic. The "Carboniferous Conglomerate" measures strike in a general east and west direction and dip either to the north or south at angles of 20° to 75°.

One mile (1·6 km.) west of East Minas station, the railway crosses Folly river. This river flows across the band of "Carboniferous Conglomerate" whose southern boundary lies ½ mile (0·8 km.) north of the railway. The strata of the conglomerate series comprise not only conglomerates but also reddish and greyish sandstones and shales with very thin seams of coal. By Fletcher the conglomerates are described as holding fragments of the "Devonian" rocks. By Sir William Dawson, the strata were classed with the "coal measures" and not with the basal Carboniferous as Fletcher did.

Beyond the crossing of Folly river, the railroad gradually approaches the southern boundary of the "conglomerate series" and finally, after curving around to a nearly north course, enters the area of these rocks. The railway passes through several cuttings in inclined red conglomerates and sandstones belonging to this series.

101·3 m. 163·0 km. **Londonderry Station**—Alt. 334 ft. (101·8m.). From Londonderry station, situated within the area of the "Conglomerate" series, the railway as it climbs the southern slope of the Cobequid hills, runs in a northeasterly direction towards the valley of Folly river. Cuttings in red conglomerate and sandstone, and in red sandstone and shale, occur along the railway. As the railway approaches Folly river, a view is afforded to the south and east over the low

Miles and Kilometres.

Triassic area along the shore of the Bay of Minas and 15 to 20 miles (24 to 32 km.) to the eastward, are visible the hills of "Devonian" strata rising on the southern side of the Salmon river valley, beyond Truro.

Where the railway enters the valley of Folly river it turns to the north, and keeping to the west of the stream, follows the valley northward across the Cobequid hills. About where the railway finally enters Folly river valley, it crosses the northern boundary of the "Conglomerate series." All along this boundary, for a number of miles to the east and west, the lowest member of the "Conglomerate series" consists of conglomerates holding pebbles and boulders up to 1 foot (30 cm.) in diameter of the bordering "Devonian" strata and of the igneous rocks that penetrate the "Devonian" and underlie by far the greater part of the area of the Cobequid hills. The "Devonian" strata in places have yielded plants precisely similar to those of the Riversdale-Union group and it is quite certain that the "Devonian" of the south flank of the Cobequid is in part at least, the equivalent of the Riversdale-Union group.

The "Devonian" beds both to the east and west of Folly river are traversed in an east and west direction, by a zone of fissuring occupied by veins of ankerite, siderite, etc., and masses of limonite and hematite. These deposits for many years were mined and the ore smelted at Londonderry.

The "Devonian" strata in general have been metamorphosed to a considerable degree. Quartz veins are common. In places the rocks are schistose, and they are penetrated by various types of igneous rocks. In these respects, they differ from the strata customarily classed as Carboniferous and therefore, notwithstanding the palæobotanical evidence, Fletcher classed them as Devonian. If the so-called "Devonian" is not Devonian but is approximately of Millstone Grit age, then the strata of the band of "Conglomerate series" to the south may be

Miles and Kilometres.

of the age of the Coal Measures as stated by Dawson, or even younger.

The zone of "Devonian" strata lying north of the belt of the "Conglomerate series" is quite narrow where crossed by the valley of Folly river. Beyond the Devonian, occurs a complex of igneous rocks that with a length in an east and west direction of about 100 miles (160 km.) forms the central part of the Cobequid hills. Where traversed by the railway, the igneous complex has not been studied petrographically but is known to contain many types including granite, diabase, and fine-grained acid and basic intrusive rocks. Areas of schistose rocks, in part of sedimentary origin, are associated with the igneous rocks.

The railway enters Folly valley at a considerable elevation above the river but in a comparatively short distance, as a result of the steep gradient of the valley bottom, the railway track and the stream possess the same altitude. The river rises in Folly lake (altitude 605 feet or 184·4 m.) along whose eastern shore the railway runs. The upper part of the valley, to the head of Folly lake, is comparatively broad and the hills on either side rise gradually to heights of 100 to 200 feet (30 to 60 m.) above the valley.

Numerous cuttings in igneous rocks occur along the railway.

108·8 m. 175·1 km. **Folleigh Station**—Alt. 618 ft. (188·4 m.). Folleigh station is situated near the head of Folly lake. Beyond the end of the lake, the valley contracts and the railway crosses a low divide (altitude 618 feet or 188·4 m.) and enters the valley of a northward flowing brook, the headwaters of Wallace river. As the divide is left behind, the valley broadens and rapidly deepens so that the railway tracks run high on the valley side. Before reaching Wentworth station the valley opens widely and the hills on either side sink abruptly to lower levels. To the north an extensive view is displayed over a low rolling country stretching northward to Northumberland strait. A band of strata of

Miles and Kilometres.

the Carboniferous Limestone series and of the Millstone Grit, several miles broad, runs along the northern flanks of the Cobequid hills while the lower country to the north is underlain by gently dipping Permo-Carboniferous strata.

113·5 m. 182·6 km. **Wentworth Station**—Alt. 472 ft. (134·8 m.). Wentworth station lies almost on the northern edge of the igneous area of the Cobequid hills. Bordering the igneous complex at this point for a length of about $2\frac{1}{2}$ miles (4 km.) in an east and west direction, is an area of Silurian rocks having a maximum width of about $\frac{3}{4}$ miles (1·2 km.). The strata consist mainly of highly inclined dark slates which in places are fossiliferous and apparently are of Clinton age.

Beyond Wentworth station, the railway enters this limited Silurian area and as it curves around to the west on the steep northern slope of the Cobequids, a splendid view is obtainable across the low country to the north. At a distance of about $1\frac{1}{2}$ miles (2·4 km.) from Wentworth station, the railway enters a belt of strata consisting largely of shales and sandstones considered by Fletcher to belong to the Carboniferous Limestone series. These measures directly overlie the igneous rocks of the Cobequid hills and with a width of 1 to 2 miles (1·6 to 3·2 km.) stretch for a number of miles both to the east and west. The strata dip northwards at angles of 10° to 40°.

118·0 m. 189·9 km. **Westchester Station**—Alt. 299 ft. (91·1 m). Westchester station is situated on the northern margin of the narrow band of the limestone series. To the north, for a width of about 2 miles (3·2 km.), the low, broken country is underlain by strata assigned to the Millstone Grit and consisting mainly of an assemblage of conglomeratic strata overlain by sandstones and shales. The strata dip to the north at angles of 30° to 12°.

119·3 m. 192 km. **Grenville Station**—Alt. 290 ft. (88·4 m.). Grenville station is situated near the northern boundary of the Millstone Grit conglomerate. The Millstone Grit sandstones and shales occupy

Miles and Kilometres.

a zone about ½ mile (0·8 km.) in width beyond which they are overlapped by Permo-Carboniferous measures dipping northward at low angles.

Beyond Grenville station, the railway follows a general northwesterly course and passes diagonally across the remaining width of the Millstone Grit. From the railway the steeply rising north front of the Cobequids is visible at intervals. Two and a half miles from Grenville station the railway enters an area underlain by Permo-Carboniferous strata. These beds terminate a short distance west of the railway but extend eastwards to New Glasgow 50 miles (80 km.) distant. The strata with very low angles of dip lie in an open synclinal fold pitching to the east. The railway in a distance of about 4 miles (6·4 km.) crosses the western end of this syncline of Permo-Carboniferous and enters an area of Millstone Grit strata dipping to the southward at low angles and extending to the northeast as a border to the Permo-Carboniferous area. To the north, an anticlinal fold brings measures of the Limestone series to the surface, while on the northern limb of this anticline the Millstone Grit followed by Permo-Carboniferous strata are again repeated.

From where the railway leaves the synclinal area of Permo-Carboniferous, to Springhill Junction, 17 miles (27·3 km.) west, the railway crosses an area in which the strata have been folded along axes pursuing a general northeasterly direction. Subsequent to the folding, the measures have been crossed by heavy faults some of which strike in a north-south direction while others follow courses that are approximately east-west, northeast-southwest, or northwest-southeast. The strata range from the Limestone series to Permo-Carboniferous and the whole assemblage behaves as a conformable series. The Limestone series is characterized by the presence of beds of gypsum and of fossiliferous limestone. The Productive Coal measures are present, and

Miles and Kilometres.

in the coal field centering about Springhill, contain 8 coal seams ranging in thickness from 2 feet to 13 feet (0·3 m. to 3·9 m.).

143·5 m.
230·9 km. **Springhill Junction**—Alt. 199 ft. (60·6 m.). A short distance to the east of Springhill Junction, the railway enters an area of Permo-Carboniferous measures lying in a broad synclinal basin that stretches westward for about 20 miles (32 km.) to the Bay of Fundy where the measures form the upper portion of the famous Joggins sections. In the neighborhood of Springhill Junction, the Permo-Carboniferous strata appear to conformably overlie Millstone Grit strata, whereas along the northern margin of the basin, they appear to conformably overlie the Productive Coal Measures.

For a distance of about 8 miles (12·8 km.) from Springhill Junction, the railway traverses the Permo-Carboniferous area. Beyond this it crosses the northern boundary of the Permo-Carboniferous and enters the band-like area of Productive Coal Measures which with a width of about 1½ miles extends easterly to the Joggins coast. Maccan Junction lies about in the centre of this band-like area.

152·6 m.
245·6 km. **Maccan Junction**—Alt. 31 ft. (9·4 m.).

ANNOTATED GUIDE.

MACCAN JUNCTION TO JOGGINS.

(G. A. Young.)

0 m.
0 km. **Maccan Junction**—Alt. 31 ft. (9·4 m.). From Maccan Junction to Joggins, the Maritime Coal, Railway and Power Company railway passes over an area underlain by the Productive Coal Measures. These beds form a band about 2 miles (3·2 km.) wide in which the strata dip southwards, at angles of 15° to 40°, beneath overlying Permo-Carboniferous measures.

Miles and Kilometres.

Leaving Maccan Junction, the railway crosses Maccan river and ascends to the top of a broad ridge (altitude 220 feet, or 67 m.). The dumps of various small collieries may be seen along the railroad line. From the summit of the ridge, the Cobequid hills are visible about 15 miles (24 km.) to the south on the opposite side of the open syncline of Permo-Carboniferous and Carboniferous strata.

After crossing the broad ridge, the railway descends to the wide valley of River Hebert.

7·1 m. 11·4 km. **River Hebert Station**—Alt. 29 ft. (8·8 m.). River Hebert station is situated near the southern boundary of the band of Productive Coal Measures and in this neighborhood are several active collieries. From this station the railway ascends the long western slope of River Hebert valley and passes through a gently rolling country (summit level, 191 feet or 60·9 m.) to Joggins.

11·6 m. 18·6 km. **Joggins Station**—Alt. 58 ft. (17·7 m.).

THE JOGGINS CARBONIFEROUS SECTION.*

(W. A. Bell.)

INTRODUCTION.

The Joggins section, Nova Scotia, is a great pile of Carboniferous rocks which faces to the north on Chignecto bay, the northern arm of the divided head of the Bay of Fundy. By the work of the powerful Fundy tides, which here rise to heights of 40 to 50 feet (12 to 15 m.), this section is happily opened to view in a flat, monotonous, waste-mantled region of few rock outcrops. Though lacking in great mineral wealth the majesty of the great thickness of Carboniferous rock exposed, as well as the ancient forests entombed therein, has won for it the homage of geologists. As to its regional importance the Joggins

*See Map—Logan's section of the Carboniferous at Joggins Mines.

section exposes an oblique cutting through an entire coal basin, known as the Cumberland Coal basin.

This basin is in the form of a broad synclinal trough, having a width of about 25 miles (32 km.), trending in a general east-northeast direction in conformity with the regional Appalachian structure, and paralleling a youthful dissected old land to the south, the Cobequid hills. To the north the basin is limited by a well defined anticline and a narrow belt of subsidiary folds, referred to as the Minudie anticlinorium, but rocks considered to be equivalent to basal members of the Joggins series extend with nearly horizontal attitudes beneath the southern lowlands of New Brunswick.

From the Chignecto shore eastward, the syncline preserves its general regularity of structure for 20 miles (32 km.) inland, where transverse folds and faults again bring up the lower rocks of the series in a belt some 12 miles (19 km.) wide, which is partially occupied by the watershed between the Bay of Fundy and Northumberland strait. From here eastward to the Strait the synclinal character of the trough is again manifest, but more noticeably interrupted by secondary parallel folds, until it sinks gently beneath the waters of St. Lawrence gulf. In the extreme southeast, however, it is no longer limited so completely by the Cobequid plateau, but, passing around several outliers of older rocks, merges into the Pictou Coal basin.

PHYSICAL FEATURES.

The whole area underlain by the Carboniferous rocks forms the Cumberland lowland, as contrasted with the pre-Carboniferous Cobequid upland to the south. The surface of the lowland is everywhere nearly plain or gently rolling, with an average elevation of little over 200 feet (61 m.) above the sea, but rising gently to the base of the Cobequids to elevations of over 300 feet (91 m.), and then rapidly to the 800 (244 m.) to 1,000 feet (305 m.) elevations of the upland surface. The monotonous character of the lower plain is broken, however, by low rolling ridges developed on the harder sub-rock, and by a few isolated monadnocks, such as Springhill (610 feet, 186 m.), Claremont hill (565 feet, 172 m.), and the Salem hills (450 feet and 390 feet, 137 m. and 180 m.). Such a residual is also present in

New Brunswick, across the bay from the Joggins, in the form of Shepody mountain, which rises to an elevation of 1,050 feet (320 m.).

Yet, properly, this Cumberland lowland is but a portion of a much more extensive Carboniferous lowland of eastern Nova Scotia and New Brunswick, whose surface is broadly characterized by its truncation and disregard of underlying structure, thus constituting a part of a true peneplaned surface which has been referred by Daly to the Tertiary epoch.

The Cobequid upland is a higher residual plateau surface representing a remnant of a once extensive and continuous uplifted older peneplain, whose several surviving portions now form the Cobequid upland, the Southern plateau of Nova Scotia, and the Caledonian and neighboring highlands of New Brunswick. Daly has correlated this higher peneplain surface with the Cretaceous peneplain of New England, and it has suffered in like manner a southeasterly tilting movement, so that the elevations progressively increase to the northwest. The Cumberland lowland is then, on this theory, but a portion of a local peneplain carved in Tertiary time in the softer Carboniferous rocks of an elevated and warped Cretaceous peneplain. The Cobequids might then be considered as a residual mass of the Unakian type.

Late Tertiary history has been expressed by oscillatory vertical movements of lesser amount, resulting in the dissection, below the general surface of the lowland, of narrow valleys whose mouths have subsequently been drowned and converted into tidal estuaries. Tidal deposition, resulting in the aggradation of wide fertile flats of marsh along the upper reaches of the Bay of Fundy, has been, aside from glacial action, the most recent and conspicuous process, and one whose activity and effects may still be observed in this region.

GENERAL GEOLOGY.

The pre-Carboniferous rocks of the Cumberland area are confined to the region of the Cobequid upland, and consist of folded and metamorphosed early Palæozoic and Pre-Cambrian (?) sediments, intruded by Pre-Cambrian (?) and Palæozoic plutonic and volcanic masses, the whole being known as the Cobequid series. Sufficiently detailed work

has not yet been done to state adequately the relations of the rocks of this complex series, but the Cobequid upland is underlain predominantly by plutonic and volcanic masses ranging in acidity from diabase to acid granites. The originally intruded sedimentary roof is present now in the central areas only as scattered remnants, but in the southern belt of the upland there is a considerable development of altered sediments, which are chiefly dark quartzites, black slates, red and green argillites, green micaceous and chloritic schists, and small areas of crystalline limestone. At Wentworth station a small outcrop of fossiliferous slates carries Silurian fossils, and Dawson on lithological grounds has assigned the remaining unfossiliferous quartzites and slates to the Silurian with the exception of a few plant-bearing beds doubtfully referred to the Devonian but which are seemingly of Pennsylvannia age.

Fletcher and Selwyn have regarded the entire Cobequid series as altered Silurian and Devonian sediments cut by post-Devonian intrusives. Ells, on the contrary, has considered these rocks as predominantly Pre-Cambrian in age, but with Cambro-Silurian sediments flanking the range on the north, and with an isolated outcrop of Silurian at Wentworth station.

The Carboniferous rocks are not exclusively confined to the Cumberland lowlands, as several outlying or inlying conglomeratic remnants occur as isolated patches on the Cobequid series.

HISTORICAL NOTES.

The Joggins section early attracted the attention of geologists by the reported occurrences of many fossilized trees still standing erect in the sandstone. In 1842 Sir Charles Lyell made his first visit to this locality and was impressed by the abundance of erect trees to be seen, as stated in one of his letters:

"Whither I went to see a forest of fossil coal-trees—the most wonderful phenomenon perhaps that I have seen, so upright do the trees stand, or so perpendicular to the strata .... trees twenty-five feet high,and some have been seen of forty feet, piercing the beds of sandstone and terminating downwards in the same beds, usually coal. This subterranean forest exceeds in extent and quality of timber, all that have been discovered in Europe put together."

Unfortunately the present stand of the fossil timber is not so striking, owing in some measure to the destructive tendencies of fossil hunters. In 1852-53 Lyell restudied the section in the company of Sir William Dawson. Since then his drawings of these logs and those of Dawson have appeared in many text books on geology.

Sir William Logan in 1843 published a careful description and detailed measurements of the northern limb of the Joggins syncline, as exposed from Mill creek at the base of the section to the uppermost beds of Shulie. In recognition of the seeming continuity in the sedimentation of his 14,570 feet (4,441 m.) of strata, he divided the section more or less arbitrarily into eight divisions, but each group was characterized on the whole by a dominance of certain characters. Fresh from his experience in the British coal fields, he was the first to appreciate the significance of the numerous ancient soil beds and underclays, so well exposed to view, as illustrating the formation of coal in situ.

Dawson in his second edition of the "Acadian Geology" in 1868 presented an accurate and very readable account of the regional geology, with many additional detailed observations on the sedimentary sequence and mode of origin of the beds, and with illustrations and descriptions of the characteristic flora and fauna.

To Fletcher and Ells of the Canadian Geological Survey are chiefly due former interpretations of the difficultly ascertained structure of the largely concealed inland portions of the basin.

DETAILED DESCRIPTION.

TABLE OF FORMATIONS.

The classification of the Carboniferous rocks as presented here is a provisional one, and the older terminology is included for comparison.

	Older classification.
JOGGINS SERIES.	
Late Pennsylvanian— Shulie formation— (Thickness 2,136 ft. (658 m.)—Logan.)	Permo-Carboniferous.
Uplift and renewed erosion.	
Middle Pennsylvanian—	
Joggins formation— (Thickness 6,886 ft. (2,099 m.)—Logan).	Productive Coal Measures.
Early Pennsylvanian—	
Boss Point formation— (Thickness 4,583 ft. (1,397 m.)—Logan).	Millstone Grit.
Disconformity.	
Mississippian— Windsor formation— (Thickness 2,000 ft. (610 m.), roughly estimated.)	Lower Carboniferous.
Unconformity.	
COBEQUID SERIES.	
Pre-Mississippian Pre-Cambrian and pre-Devonian altered sediments.	
Pre-Cambrian and Palæozoic igneous intrusives.	

The Joggins section is naturally divisible into five major divisions, none of which is sharply delineated, but each is the effect of peculiar conditions of sedimentation. These are briefly: (a) a lower marine limestone and red shale division of Mississippian age, called the Windsor formation; (b) a conglomerate, grey sandstone, and shale division of Pennsylvanian age, of fresh-water origin, and containing plant remains and thin coal seams, comprising the Boss Point (Millstone Grit) formation; (c) a barren red shale division included in the succeeding Joggins formation; (d)

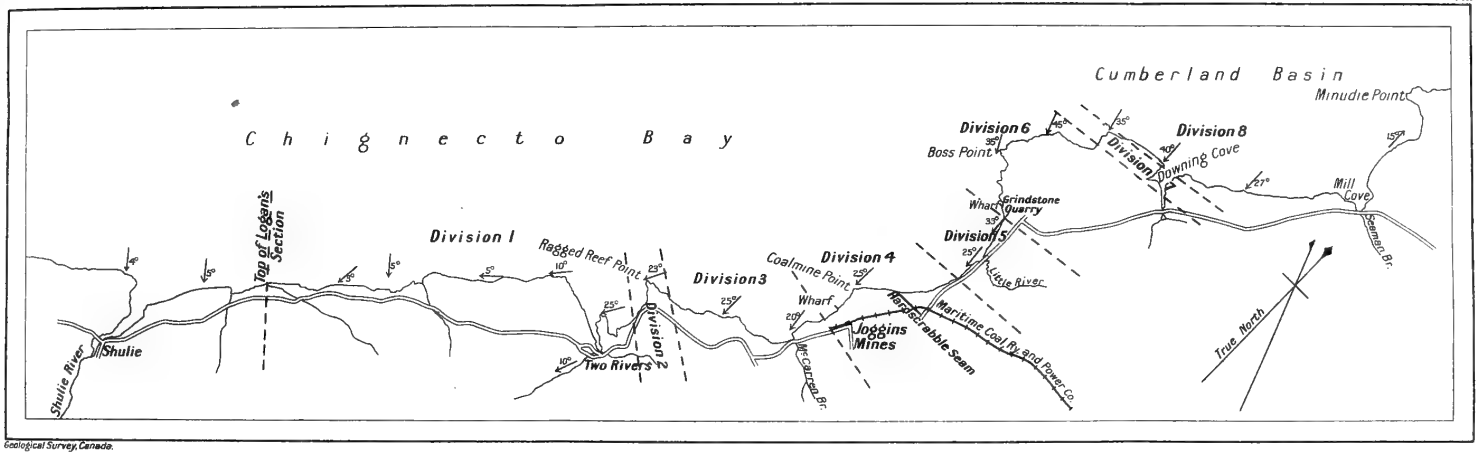
a sandstone and shale division of terrestrial origin, with plant remains and productive coal seams, forming the typical Joggins formation; and lastly (e) an upper conglomeratic division also of terrestrial origin, comprising the Shulie formation. A brief description of each formation is given below.

LOWER PART OF SECTION: TO LOWER COVE.

Windsor formation.— Below the Joggins section, in the axial region of the Minudie anticlinorium, near Minudie, there may be seen at low tide some 50 feet (15 m.) or more of black and nodular limestone, associated with red and green shales and calcareous sandstones. The calcareous beds carry a scanty fauna related to that of the upper limestone at Windsor, of Mississippian age. The extension of these beds at Nappan and across the bay in New Brunswick is associated with a thick zone of gypsum, but this mineral is concealed in the low area below the Joggins section. Lying conformably above these definitely marine beds, there are upwards of 2,000 feet (610 m.) of barren, brick red, arenaceous and argillaceous shales, of which the upper 966 feet (299·4 m.) are well exposed at the base of the Joggin section. These soft red beds underlie a belt of low country about $2\frac{1}{2}$ miles (4·2 km.) in width, striking in an easterly direction from Cumberland bay to the river Hebert. The shales contain abundant flakes of mica, and from their rippled, mud-cracked and cross-bedded character are believed to be the deposits of a receding Mississippian sea and are hence included in the Windsor formation.

A greater development of the beds is exposed across the bay in New Brunswick where the upper deposits are distinctively calcareous, the lime occurring in the form of thin beds, seemingly of chemical deposition, or as numerous concretions in bright red shales and conglomerates. These rocks dip uniformly about 27° southward.

Post-Mississippian unconformity.— Post-Mississippian orogenic movements followed by uplift and erosion before the deposition of the Pennsylvanian rocks, are marked in many areas of Nova Scotia and New Brunswick by erosional unconformities. At the Joggins section, however, the unconformity is accordant, and is therefore distinguished by the term disconformity. It occurs at the



Geological Survey, Canada.

Logan's Section of the **Carboniferous** at **Joggins Mines**

Miles
0 1 2 3

Kilometres
0 1 2 4

base of the lowest bed of grey sandstone in the Boss Point formation. These overlying Boss Point beds are characterized by the presence of grey sandstone bearing abundant, though frequently generically obscure, drift plant debris indicative of Pennsylvanian time, and by the occurrence of basal quartz conglomerates seemingly derived from the erosion of upper beds of the underlying Windsor. The geological history represented by this depositional break must be largely of a speculative nature until further regional data are obtainable.

It is probable, however, that the Cobequid mountains were established as a region of uplift in early Palæozoic times, and partook of the orogenic movements of late Silurian and post-Silurian times, which took place generally in western New England, and still later possibly they may have suffered post-Devonian deformations. At least the faunal and structural evidence points to the existence of the Cobequids as highlands or islands in the Mississipian sea. The post-Mississippian orogenic movements were Appalachian in character with the thrust from the south, and highly disturbed the Windsor strata in the basin south of the Cobequids, but seemingly little affected these to the north of the Cobequids. Contemporaneous or later vertical movements then initiated a period of active erosion and the deposition of terrestrial deposits in the form of fluvial flood plains and subaerial delta deposits which were derived in part from the large continuous areas of upland to the south and west, and in part from the forelying Appalachian mountain chains. Of these mountain ridges, the Cobequids were sufficiently developed to delineate the two main Carboniferous basins of Nova Scotia. The southern or deeper basin which lay between the Cobequids and the Southern uplands was an area of estuarine or brackish-water deposition resulting in the Riversdale deposits. In the north the Cumberland and the southern New Brunswick basins were seemingly continuous and this area was one of contemporaneous terrestrial fluvial deposition, giving rise to the Boss Point (Millstone Grit) sediments.

Boss Point Formation—The Boss Point formation continues westward from the Windsor belt for about 5 miles (8 km.), and consists primarily of two distinct divisions, a lower prevailingly red division, and an upper predominantly grey division. The lower division contains considerable conglomerate which is characterized by the

presence of well rounded pebbles of varicolored vein quartz and quartzites, embedded in a matrix of sharp or subangular sand grains and red ferruginous cement, the pebbles ranging in size up to 3 inches in diameter. In addition, occasional grey limestone pebbles occur. Within this formation, as exposed in the Joggins section, siliceous conglomerates are confined to these basal members, but in New Brunswick, conglomerate is, however, as mentioned above, of common occurrence, not only in the lower division, but throughout the formation, in the form of lenticular beds which channel into the underlying grey sandstones or shales.

The succeeding division is the one especially characteristic of this formation, and consists mainly of greenish grey, yellow or buff weathering sandstones interbedded with brick red argillaceous shales, but with subordinate grey and black carbonaceous shales, as well as thin seams of coal and of fossiliferous bituminous limestone. The latter may carry *Leperditia*-like ostracods, *Anthracomya ovalis* (Dawson), *A. laevis* (Dawson), coprolites as well as scales and teeth of Crossopterygian and Chondrostean ganoids. The flora has not yet been worked out in detail, but the commonest forms are drifted trunks of *Dadoxylon acadianum* Dawson, *Calamodendron*, *Stigmaria ficoides* Brongniart, *Sigillaria*, *Calamites* and leaves of *Cordaites*, all of which are also found in the succeeding formation.

Middle part of section: Lower Cove to McCarren Brook.

The typical sharp quartz sandstone of the formation occurs at Boss point and at an abandoned quarry at Lower cove, where, in the past, the rock from the reefs was extensively worked into grindstones. The frequent occurrence, however, of hard concretions and of drifted plant material must be a serious defect of this stone.

Joggins Formation—The sandstones of the quarry at Lower Cove are succeeded by 2,000 feet (610 m.) of red beds which because of their lithological contrast with the underlying Boss Point measures, and for other reasons, indicate the possibility of a disconformity existing beneath this horizon and are therefore classed with the Joggins formation.

It is thought that the 2,000 feet of red shales may be the equivalent of certain red conglomerate and associated

strata occurring at Spicer's Cove at the western end of the Joggins section. It should be stated however that the conglomerates, etc., of Spicer's Cove were held by Fletcher to possibly represent the New Glasgow conglomerate and therefore to be of Permo-Carboniferous age. It is interesting to note here that a somewhat similar thickness of brick red conglomerates, soft sandstones and shales occurs in a belt immediately to the north of the Minudie anticlinorium in New Brunswick seemingly overlapping the Boss Point beds unconformably, suggesting that these too may represent in part synchronous deposits of the Joggins formation but with the material largely derived from the New Brunswick highlands to the north(?) and west. This is supported, moreover, by the fact that fragments of a very poorly preserved *Lepidodendron* like that of a species commonly occurring in the Joggins formation have been seen in these rocks. These rocks have been mapped by Ells as Permo-Carboniferous.

Aside from their importance in the above theoretical consideration, these almost barren red beds are without any special interest. Their softness in comparison with the rocks above and below has resulted in the formation here of a low depression. From any point along this shore, however, may be had an excellent view of the succeeding rocks of the Joggins formation, which are exposed continuously with great regularity of dip (20°+) for more than 4 miles (6·5 km.) or to the vicinity of Ragged Reef point. On a clear day this view may be extended across the bay into New Brunswick where the monadnock mass of Shepody mountain may be clearly seen, rising conspicuously above the gently sloping plains of Carboniferous rocks which there form a low foreland 4 miles (6 km.) in breadth, skirting the Caledonian upland. The Carboniferous rocks there exposed belong exclusively to the Windsor and Boss Point formations, and the Cumberland syncline apparently curves sharply to the south underneath the waters of Chignecto bay. Even from the Joggins shore, the rocks of the Boss Point formation may be seen to strike uniformly in a westerly direction across to the Maringouin cape, but along the farther shore of the New Brunswick mainland they strike southwesterly about parallel to the coast and dip steeply at angles greater than 45° beneath the bay.

Shepody mountain itself lies in line with the Minudie anticlinal, which may then be considered as deflected to the

southwest parallel to the present outline of the New Brunswich coast. The Carboniferous area lying to the westward of Shepody mountain is therefore an integral part of the Cumberland synclinorium, or it represents more properly the extension of the Minudie anticlinorium.

The remaining strata of the Joggins formation are the most interesting in the Joggins section both on account of their organic remains and their economic importance. The beds differ from the preceding beds of the Boss Point formation chiefly in those characters resulting from deposition under more pluvial or swampy conditions. Thus the measures are predominantly grey in color, the sandstones are generally much thinner, and are replaced or interbedded with thick or thin zones of red, grey, or variegated shales in which the coals or carbonaceous beds occur. It will be seen that the division of this formation into unequal zonal groups may be conveniently made in the field, since there is a noticeable monotonous sequence of zones of regularly evenly-bedded shales, thin sandstones, underclays, coals and thin bituminous limestones, in alternation with massive falsely-bedded sandstones that characteristically channel into the underlying shale zones. The rapid deposition of these heavier sandstone beds is well attested by the fact that they frequently contain the casts of erect trees which occasionally exceed 20 feet in length and whose bases occur in the mudstone soils beneath. That these soil beds are extremely abundant throughout the whole formation, may be seen from the widespread vertical recurrence of shale beds with rootlets (*Stigmaria*).

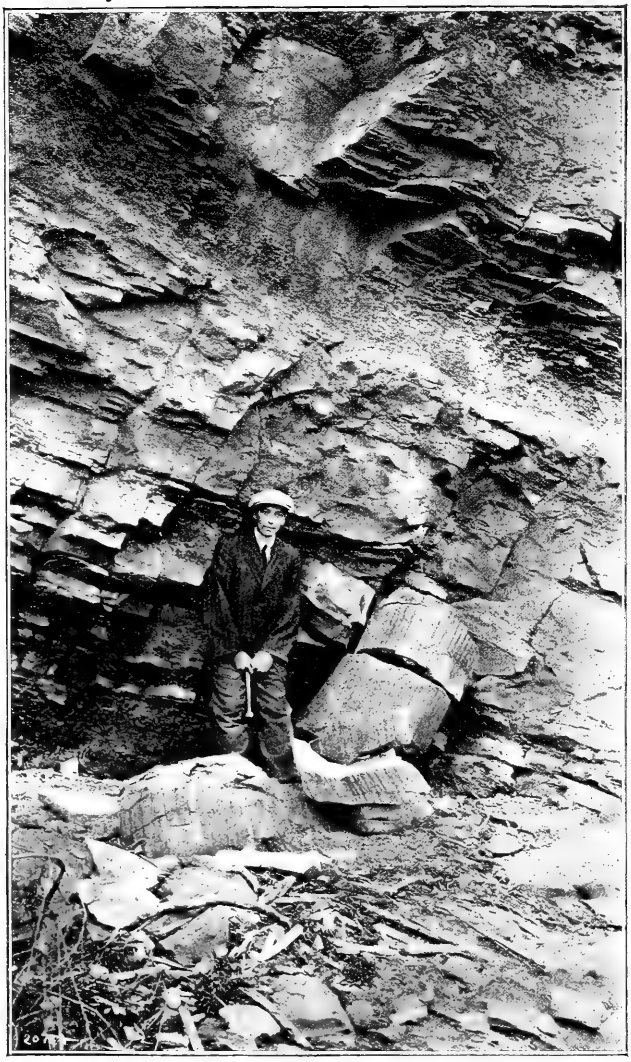
As a consequence of the presence of such abundant organic material much of the ferric iron contained in the sandstones and shales has been reduced to a more soluble salt. This process has been accompanied by a leaching action and deprivation of iron from these beds, which has been supplemented by concentration and redeposition of the iron in the shales in the form of argillaceous hydrated carbonate (ironstone) concretions. The above characters of this formation are illustrated in the first rocks encountered at the high cliff. The first zone of evenly-bedded red shales has associated with it the first coal group, which consists of three minute seams of coal or coaly matter, each less than one inch in thickness, but each underlain by a distinct *Stigmaria* underclay. The regularity of these beds is abruptly and unevenly terminated above by the succeeding

10 feet of reddish grey ill-sorted sandstone, but the latter passes up into a second zone, 46 feet in thickness, of evenly-bedded, red shales without coals, which is likewise cut off by 9 feet of greenish grey coarse sandstone. The succeeding third zone of regular strata includes an interesting and characteristic coal group, where the coals are intimately associated with thin beds of black bituminous fossiliferous limestone. One of these coals has a floor of this dirty limestone, and although the characters of the limestone floor would not seem to furnish a good forest soil, yet nevertheless, this limestone has in it abundant Stigmaria with the attached radiating rootlets, again furnishing evidence of the formation of this coal *in situ*. The upper limestones in the roof carry crushed pelecypod shells of genus *Anthracomya* associated with a tubicular annelid shell, *Spirorbis carbonarius* Dawson, Leperditian ostracods including *Cythere* and fish scales. This coal group like many of the following provides few plant remains. Dawson states however that the coal itself has Cordaites and vascular bundles of ferns associated with vascular tissue of Sigillariæ.

The succeeding 40 feet or so in this group is mainly grey shales containing ironstone balls, and with subordinate carbonaceous seams carrying a fauna similar to the above. Three erect trees, poorly preserved, with coaly streaks marking traces of the old roots, were observed here in the summer of 1912, embedded in the shales but penetrating the coarsely-bedded sandstone above. Several upright Calamites were also noted arising from the base of the sandstone bed. The succeeding strata may be similarly marked out for convenience into zones as the contrast between the regularly bedded strata of the coal and shale zones and the irregular and cross-bedded sandstone zones is usually quite marked.

Erect trees—The number of erect trees to be seen in the following rocks varies of course from year to year with the seasonal wearing back of the cliffs. Their abundant occurrence and position perpendicular to the bedding, is alone good evidence that they are preserved in the position of their growth, *i.e.*, *in situ*.

On close examination it will be seen that in almost every case where the roots are absent, the trunks are abruptly terminated downward either by a coal seam or by a thin seam of carbonaceous shale. The cases indeed are very



An upright fossil tree. Joggins, N.S.

few in which the rhizomes or roots are preserved, but apparently in every case where the trunks stand in shale independently of a coaly seam, some traces of the roots may be seen. Several of such have been observed, where in each case the trunk was attached to roots (rhizomes) of *Stigmaria ficoides* aspect. As the great majority of the trees are sandstone or mudstone casts replacing the interior, only the markings of the deeper cortical surfaces are reproduced as surface markings on the casts. The bark itself, however, is frequently preserved as a coaly coating which may show imperfectly the internal cellular structure. Dawson has carefully worked out the structures of these trees and accompanying flora, and has stated that the greater number of the erect stumps preserved at the Joggins are *Sigillariæ* which have also contributed very largely to the formation of the coals. In fact all of these Joggins coals show unequivocal evidence of *Stigmaria* in their underclays, with the exception of a few thin shaly beds which are filled with drifted leaves. Every underlcay or soil bed, however, does not necessarily bear a coal seam above it.

Dawson has enumerated five species of *Sigillariæ* from the Joggins of which *S. brownii* Dawson, and *S. elegans* Brongniart are the two commonest. The roots of the *Sigillariæ*, or *Stigmariæ*, are the most abundant fossils in the sections but seemingly they are not readily determined specifically, and the greater number are included under the species *Stigmariæ ficoides*.

Associated with these standing forests of *Sigillariæ* are those of *Calamites*, but, whereas the former are embedded at their base in the argillaceous shales, the Calamite brakes terminate most commonly in the arenaceous beds. At the Joggins seven species have been recognized, of which *C. suckovi* Bron. and *C. cistii* Bron. are the most prevalent.

The remaining type of tree standing in an erect position is preserved as pillars of coaly matter or of mineral charcoal, occasionally calcified, which do not show external marking but whose microscopic structure has determined them to be coniferous (Dawson), and which therefore probably represent remains of *Cordaites*. These are rarely seen except in the upper portions of the Joggins formation and in the following Shulie formation.

Flora of the Joggins Section—The remaining flora of the Joggins formation is a drifted one, and for a coal region

is noticeably meager. The Lycopods are much less abundant than Sigillariæ, and are represented only by six identified species of which *Lepidodendron rimosum* Dn., *L. elegans* Dn., and *L. pictoense* Dn., are the most common. There are in addition several species of the related *Lepidophloios* of which might be mentioned *L. acadianus* Dn., *L. parvus* Dn., and *L. prominulus* Dn. Moreover detached Lepidodendroid axes, assigned to the genus *Ulodendron* occur, as well as the detached Lepidodendroid leaves known as *Lepidophyllum*, and fertile shoots or strobile classified as *Sporangites*. The great group of Pteridosperms is next in importance, but is seemingly remarkably deficient in representative species. They include *Alethopteris tonchitica* Sternb. *Sphenopteris latifolia* Bron., *Pecopteris lonchitica* Dn., *Cyclopteris* sp., including seeds doubtfully referred here, e.g., species of *Trigonocarpum*. The additional filicales *Caulopteris* (*Psaronius*) sp., *Megaphyton* (*Psaronius*) *humile* Dn., and *M. magnificum* Dn., may be representatives of the true ferns.

From the beginning of the cliff to the old wharf at the Hardscrabble coal seams, little plant material will be seen, but from the wharf to beyond the Joggins Coal mine, the material is more abundantly found. A nearly complete list of the identified species of the flora and fauna is appended at the close of this account.

Fauna of the Joggins formation—The invertebrate remains are confined almost exclusively to the thin beds of limestone and carbonaceous shales, which probably represent the consolidated mucks of stagnate lakes or lagoons which occurred in the marshy flats. The chief organic remains are crushed shells of *Anthracomyas* or *Naiadites*, of which several species may be recognized, and of smooth Leperditoid ostracods assigned by Dawson to the genera *Cythere* and *Bairdia*. Associated with these remains are the excrement, scales, spines and occasionally the teeth of fish. Of the shark-like types there occur the skins and teeth of *Ctenoptychius cristatus* Dn., *Diplodus* sp., *Gyracanthus duplicatus* Dn., of the Crossopterygian and Chondrostean ganoids, scales of *Rhizodus*, and *Palæoniscus*; while the Dipnoi may be represented by teeth of the genera *Conchodus*.

In common association with the above remains, but especially in attachment to the drifted plant debris, are

found abundant coiled annelid tubes of the species *Spirorbis carbonarius* Dn.

The greatest interest in the Joggins fauna has, however, been directed to the land vertebrate remains which are found in the basal carbonaceous deposits and always in the upright Sigillariæ tree stumps. These all belong to the Stegocephalian amphibians, and are comprised under three main genera, *Dendrerpeton*. *Hylonomus* and *Hylerpeton*. An interesting associate with these forms is the delicate land snail shell, *Pupa vetusta* Dn., which likewise occurs in a few of the shale soils in company with another land shell, *Zonites priscus*, Carpenter. Within the strata proper no amphibian remains have been found with the exception of footprints referred to *Dendrerpeton*, and the single vertebra of *Eosaurus acadianus* Marsh, which was discovered by Marsh west of the coal mine near McCarren brook.

UPPER PART OF SECTION: McCARREN BROOK WESTWARD.

Between McCarren brook and Ragged Reef point, sandstones become again dominant, and the coal groups, although 22 in number, are of very minor importance, but interesting in the fact that they are all accompanied with Stigmarian undersoils. Beds of limestone are entirely lacking in this part of the formation, and in general the effects of swampy conditions are much less evident. Thus the shale zones are prevailingly red in colour, and almost lacking in organic remains with the exception of traces of small rootlets, suggesting conditions of thorough oxidation as well as dessication upon the original mud flats. Erect trees are here rare and the vegetation in general is much more scanty. On the other hand, channelling action of the sandstones and sudden lateral replacements are more conspicuous than before, though evidences of strong current action are not so prevalent as in the succeeding Shulie formation.

Post-Joggins uplift and erosion—The peculiarities of the succeeding Shulie formation are the emphasizing features of strong current action. The beds are dominantly coarse or conglomeratic, and the greater percentage of the pebble content may be readily traced by lithological comparison to its source in a Cobequid upland. Furthermore, the size of the individual pebbles increases towards the

old land. For, whereas the pebbles north of Shulie are in general less than 2 inches in diameter, those in the Apple River conglomerate frequently exceed 12 inches. The presence of a considerable percentage of sandstone and shale pebbles of Pennsylvanian aspect is additional evidence in support of a renewed activity of erosion in the Cobequid area in Upper Pennsylvanian time. But corroborative evidence is also found in the structures of the beds themselves, not only in their unsorted and uneven characters, but in the appearance of the bedding plane of the pebbly sandstones or conglomerates. These show a markedly uneven surface in the presence of great ripples or more properly crests and hollows of a flow and plunge structure. The distance from crest to crest frequently exceeds 10 feet (3 m.) while the furrows may be several feet in depth.

As some beds of the Joggins formation have been stated to have passed over at least a portion of the Cobequids it seems necessary to explain these phenomena by a renewed uplift and erosion of the Cobequid area in post-Joggins time. The continuity of the sedimentation in the central areas of the Cumberland basin seems not to have been disturbed, but an unconformity or disconformity, representing a great time interval, must exist in the borderland of the Cobequids at Spicer's cove as apparently only the basal members of the Joggins formation are there preserved.

Shulie formation.—The main characters of the Shulie formation have been stated above. The flora is meagerly represented by large calcified drift trunks of *Dadoxylon materiarium* Dn., and of drift fragments of *Calamites suckovi* Bron., *C. cistii* Bran., *Calamodendron approximatum* Dn., *Lepidodendron undulatum* Gutbier, *Lepidophloios parvus* Dn., *Lepidophyllum lanceolatum* Lindley and Hutton, *L. trinerve* Dn., erect *Calamites*, erect *Sigillariæ?*, erect conifers (*Dadoxylon?*), *Sphenopteris hymemophylloides* Bron., *Alethopteris lonchitica* (Sternb.), *Cyclopteris heterophylla?* Dn., *Beinertia goepperti* Dn.

The above flora is, according to Dawson, distinct in assemblage of forms from the preceding floras of the Boss Point and Joggins formations, though still retaining persistent types, such as *Alethopteris lonchitica* (Sternb.), *Calamites suckovi* Bron., and *C. cistii* Bron. It suggests, however, as stated by Dawson, Upper Pennsylvanian time, and not Permian, as *Lepidodendra* and *Sigillaria* still hold a prominent position.

JOGGINS FAUNA.

Annelida
  Spirobis carbonarius Dawson.
Pelecypoda
  Anthracomya elongata Dawson.
  A. laevis Dawson.
  A. ovalis Dawson.
  Naiadites carbonarius Dawson.
  N. longus Dawson.
Gastropoda
  Pupa vetusta Dawson.
  Zonites (*Conulis*) *priscus* Carpenter.
Crustacea
  Ostracoda
    Bairdia
    Cythere
  Myriopoda?
    Xylobius sigillariae Dawson
  Amphipoda?
    Diplostylus dawsoni Salter.
  Merostomata
    Eurypterus? DeKay.
Pisces
  Elasmobranchii
    Ctenoptychius cristatus Dawson.
    Diplodus.
    Gyracanthus duplicatus Dawson.
    Psammodus.
  Dipnoi
    Conchodus
  Crossopterygii
    Rhizodus.
  Chondrostei.
    Palaeoniscus.
Amphibia (Stegocephali)
  Temnospondyli
    Dendrerpeton acadianum Owen.
    D. oweni Dawson.
    Dendrerpeton? footprints.
  Microsauria
    Hylerpeton dawsoni Owen.
    Hylonomus aciedentatus Dawson.
    H. lyelli Dawson.
    H. wymani Dawson.
  Stereospondyla
    Eosaurus acadianus Marsh.

Pteridophyta (vascular cryptogams)
- Equisetales
  - *Calamites cannaeformis* Schlotheim.
  - *C. cistii* Brongniart.
  - *C. nodosus* Schlotheim.
  - *C. nova-scoticus* Dawsom.
  - *C. pachyderma* Brongniart.
  - *C. suckowi* Brongniart.
  - *Calamodendron approximatum* Brongniart.
  - Detached foliage and leaves of Calamites.
    - *Calamocladus* (*Asterophyllites*).
    - *Annularia.*
  - Roots of Calamites?
    - *Pinnularia ramosissima* Dawson.
- Sphenophyllales
  - *Sphenophyllum schlotheimii* Brongniart.
- Lycopodiales
  - *Lepidodendron aculeatum* Sternberg.
  - *L. dichotomum* Sternberg.
  - *L. elegans* Brongniart.
  - *L. pictoense* Dawson.
  - *L. rimosum* Sternberg.
  - *L. undulatum* Gutbier.
  - *Lepidophloios acadianus* Dawson.
  - *L. parvus* Dawson.
  - *L. platystigma* Dawson.
  - *L. prominens* Dawson.
  - Lepidodendroid axes.
    - *Uloderdron* of *majum* Lindley & Hutton.
    - *U.* cf. *minum* Lidldey & Hutton.
  - Detached leaves of Lepidodendra.
    - *Lepidophyllum.*
  - Fertile shoots or strobile of Lepidodendra.
    - *Sporangites glaber* Dawson.
    - *S. papillatus* Dawson.
  - *Sigillaria brownii* Dawson.
  - *S. catenoides* Dawson.
  - *S. elegans* Brongniart.
  - *S. schlotheimana* Brongniart.
  - *S. scutellata* Brongniart.
  - Sigillaria leaves.
  - Sigillaria rhizomes or roots.
    - *Stigmaria ficoides* Brongniart.

Filicales (chiefly Pteridospermae).
Alethopteris lonchitica Sternberg.
Caulopteris (*Psaronius*).
Cyclopteris.
Megaphyton (*Psaronius*) *humile* Dawson.
M. magnificum Dawson.
Pecopteris lonchitica Dawson.
Sphenopteris latifolia Brongniart.
Seeds of Pteridospermae?
Trignoncarpum avellanum Dawson.
T. intermedium Dawson.
T. minum Dawson.
T. sigillariae Dawsom.
Cordaitales.
Araucarites (*Dadoxylon*) *gracilis* Dawson.
Cordaites borassifolius Sternberg.
Dadoxylon (*Araucarioxylon*) *annulatum* Dawson.
D. materianum Dawson.
Pith casts of Cordaites.
Sternbergia artis Dawson.
Seeds of Cordaitales.
Rhabdocarpus Goeppert and Bergeron.
Fertile stems of Cordaitales?
Antholites Brongniart.
Cardiocarpum fluitans Dawson.

INDUSTRIAL NOTES.

The main coal seams were worked at the Joggins as early as 1826, by shaft and horse-gins, but previous to 1854 the total production was only 7,700 Newcastle chaldrons (a chaldron = 72 bushels).

The Joggins mine, at present, is owned and operated by the Maritime Coal Railway and Power Company, Ltd. The seam in the Joggins mine is 3 feet 6 inches (1·06 m.) in thickness. The slopes pitch about 17° at an angle slightly less than that of the seam, and at present are 3,600 feet (1,096 m.) from the surface to the face of sinking. The total output for 1911 was 149,670 tons. In 1912 the output was 600 long tons per day.

The same company owns and operates in the same field the Minudie mine, Black Diamond mine, Maple Leaf and Chignecto mines, which together produced 71,315 tons

in the year 1911. In addition, the Kimberley mine is owned and operated by the Minudie Coal Company.

No definite correlations have yet been made of the seams worked in these various colleries, although it is probable that some are equivalents of the Hardscrabble and overlying seams. The dips of the coals increase inland from 19° south at the Joggins to 40° south at the old Styles mines, 12 miles (19·3 km.) inland. Beyond this the basin is apparently interrupted by transverse folding and faulting.

About 6 miles (9·6 km.) south of the Styles area, in the southern limb of the Cumberland synclinorium, there is situated a coal basin known as the Springhill basin, which embraces seams of greater economic importance. Of these, three are worked which are respectively 5 feet 6 inches (1·7 m.), 8 feet 4 inches (2·5 m.), and 10 feet 6 inches to 4 feet 2 inches (3·2 m. to 1·3 m.) in thickness. The dips vary from 20° to 80° westerly. The precise relation of this basin to that of the Joggins is still one of speculation, although the measures undoubtedly belong to the Joggins formation.

BIBLIOGRAPHY.

Dawson, J. W.....Acadian Geology.

Fletcher, Hugh.....A section of the Carboniferous Rocks in Cumberland County, N.S., Proc. and Trans. Nova Scotian Inst. of Sci., Vol. XI, part 3, pp. 417-550, 1908.

Logan W. E.....Geol. Surv. Can., Report of Progress, 1845.

ANNOTATED GUIDE.

MACCAN JUNCTION TO MONCTON.

(G. A. YOUNG.)

Miles and Kilometres.

0 m.
0 km. **Maccan Junction**— Alt. 31 ft. (9·4 m.). From Maccan Junction the Intercolonial railway runs northward following for some distance the eastern side of Maccan river. About ½

Miles and Kilometres.

mile (0·8 km.) beyond Maccan Junction, the railway crosses the northern boundary of the Productive Coal Measures and enters a narrow belt of Millstone Grit beds which dip beneath coal measures. Where traversed by the railway, this band of Millstone Grit has a width of about $\frac{3}{4}$ mile (1·2 km.). The country traversed is low. To the west are visible the highlands on the New Brunswick shore of the Bay of Fundy, distant about 18 miles (28 km.). The high. detached hill is Shepody mountain composed of lower Carboniferous strata. The continuous, somewhat lower upland beyond Shepody mountain, is Caledonia mountain which stretches westward for many miles parallel with the shores of the Bay of Fundy and is formed chiefly of Pre-Cambrian strata.

The Millstone Grit strata are succeeded on the north by a wide area of the Carboniferous Limestone series in which the strata dip southward at angles of 20° to 40°. These measures where traversed by the railway occupy a belt about $3\frac{3}{4}$ miles (6 km.) wide. Towards the northern edge of this belt, the railway passes close to a gypsum quarry, visible on the western side of the railway.

About 5 miles (8 km.) beyond Maccan Junction, the railway enters a broad band of Permo-Carboniferous strata stretching westward from the head of the Bay of Fundy to the shores of Northumberland strait. These measures overlap the Carboniferous Limestone series on the south.

8 m.
12·9 km.

Amherst—Alt. 63 ft. (19·2 m.). The very low country around Amherst is underlain by gently dipping reddish sandstones and shales of Permo-Carboniferous age. These measures extend northeastward to Cumberland strait, distant about 20 miles (32 km.). The tract of country between the head of the Bay of Fundy and the Gulf of St. Lawrence is everywhere low, probably nowhere reaching an altitude greater than 100 feet (30 m.).

Miles and Kilometres.

From Amherst, the railway runs in a general westerly course and approaches close to the head of the Bay of Fundy. About 4 miles (6·4 km.) beyond Amherst the railway enters a narrow belt of country believed to be underlain by Millstone Grit. This belt is about $1\frac{1}{2}$ miles (2·4 km.) wide and extends to the northeast where it is marked by a low ridge. This band of Millstone Grit extends in a westward direction across the head of the Bay of Fundy and there rises in a marked ridge.

14·2 m.
22·8 km.

Aulac Station—Alt. 26 ft. (7·9. m.). Aulac station is situated near the northwestern margin of the presumably anticlinal band of Millstone Grit. The low country beyond and the rising ground towards the west are occupied by reddish Permo-Carboniferous strata dipping over the greater part of the area to the southwest at angles of 15° to 30°. Between Aulac station and Sackville, the railway passes around the extreme head of the Bay of Fundy.

17·9 m.
28·8 km.

Sackville Station—Alt. 26 ft. (7·9 km.). The low country about Sackville presumably lies on the axis of a synclinal fold in Permo-Carboniferous strata. These measures extend for about $1\frac{1}{2}$ miles (2·4 km.) to the south to the foot of a ridge of northward-dipping Millstone Grit beds. To the northwest of Sackville, the Permo-Carboniferous strata dip southwards at angles of 20° to 30° and rise in a series of ridges 400 to 600 feet (120 m. to 180 m.) high. On the top of this upland, Millstone Girt strata appear from beneath the Permo-Carboniferous without any evidence of an unconformity.

From Sackville the railway runs westerly up a valley near the southern margin of the Permo-Carboniferous area and for some miles continues to ascend. Beyond the head of the valley the railway crosses a divide with an altitude of 234 feet (71·3 m.), and a short distance beyond crosses the northern boundary of the Permo-Carboniferous area and enters a district occupied by Millstone Grit strata. As the railway continues to descend, it enters and follows a

Miles and Kilometres.

pronounced valley which eventually turns to the west and joins the broad valley of Memramcook river. Before entering this main valley, the railway passes through a long cutting of grey Millstone Grit sandstone dipping southward at an angle of 20°.

On entering the Memramcook valley, the railway bends to the north and traverses the low diked land bordering the river. On the opposite shore of the river rises a rounded ridge of Millstone Grit grey sandstone and quartz conglomerate dipping southward at low angles. Before reaching Dorchester station the railway passes out of the Millstone Grit area and enters one occupied by a coarse red conglomerate of lower Carboniferous age. The two formations dip to the southward at angles of 10° to 25° and appear to be conformable though they are presumably of widely different ages.

29·3 m. 47·1 km. **Dorchester Station**—Alt. 27 ft. (8·2 m.). Beyond Dorchester station the rising ground on the east is occupied by red conglomerates and sandstones capped on the summits of the ridges by the grey strata of the Millstone Grit. Approaching Upper Dorchester station, the low-lying ground immediately adjacent to the railway is underlain by strata of the Albert series which have been correlated with the Horton series of Nova Scotia, and are considered to be of early Carboniferous age.

32 m. 51·5 km. **Upper Dorchester Station**—Alt. 27 ft. (8·2 m.). On the western side of Memramcook river, just above the highway bridge at Upper Dorchester, are low cliffs of the Albert series which at this point lie in a flat anticline. The strata in these low cliffs are dark shales or "oil-shales" very rich in hydro-carbons. The lower slopes of the rising ground west of the river are occupied by gently dipping red sandstones and grits while the summit of the ridge is formed of the grey sandstone and quartz conglomerate of the Millstone Grit. On the opposite side of the ridge somewhat similar strata occur overlying the Albert series which,

Miles and Kilometres.

as exposed in several detached areas, dip with high angles in various directions.

North of Upper Dorchester station, the railway again enters an area underlain by Albert strata and these are capped by coarse grey Millstone Grit conglomerate forming a low ridge rising just east of the railway.

34·9 m. 56·2 km. **College Bridge Station**—Alt. 32 ft. (9·7 m.). In the vicinity of College Bridge station the Albert series underlies a very limited area on the east side of the river. On the west side of the river, this series with its "oil-shales" is more fully developed over a band about 1 mile (1·6 km.) wide which extends in a northwesterly direction for about 6 miles (9·6 km.) to the banks of the Petitcodiac river, opposite the Stony Creek oil and gas field.

A short distance beyond College Bridge station, the railway again enters an area underlain by lower Carboniferous strata—red shales, sandstones and conglomerates. These measures occupy the lower slopes of the ridges bounding the Memramcook valley but the summits of these hills are capped by nearly horizontal grey, Millstone Grit sandstones and conglomerates.

As the railway follows northward up the Memramcook river, the valley gradually contracts. About $4\frac{1}{2}$ miles (7·2 km.) beyond College Bridge station, the railway passes through a series of cuttings in granite. These exposures belong to an area of granite having a maximum diameter of about $\frac{1}{2}$ mile (0·8 km.) and which apparently represents an island-like projection of the floor on which the Carboniferous measures were deposited.

41·5 m. 66·8 km. **Calhoun Station**—Alt. 54 ft. (16·4 m.). Beyond Calhoun station the valley of Memramcook river becomes very shallow and gradually dies away. The surrounding country is very even in character and is presumed to be underlain by nearly horizontal strata of Millstone Grit age. Four and a half miles (7·2 m.) beyond Calhoun station the railway crosses a

Miles and Kilometres.

low summit (altitude 180 feet or 54·8 m.) and commences to descend to the valley of Petitcodiac river.

48·6 m. 78·2 km. **Painsec Junction**—Alt. 149 ft. (45·4 m.). The gently rolling country to the west of Painsec Junction is underlain by nearly horizontal red shales and sandstones, interbedded with grey sandstones, all of Millstone Grit age. From several points along the railway a comparatively high ridge is visible to the north. This ridge is formed in part of sedimentary strata and possibly in part of igneous rocks. It is probable that the Albert series is represented in this ridge but it is not improbable that the strata are chiefly of pre-Carboniferous age.

56 m. 90·1 km. **Moncton**—Alt. 50 ft. (15·2 m.). Moncton is situated on the north side of Petitcodiac river where this river after flowing for a number of miles in an easterly direction, abruptly turns and pursues a southerly course as far as its mouth where it empties into the Bay of Fundy.

MONCTON—ALBERT MINES.*

(G. A. Young.)

INTRODUCTION.

Moncton is situated near the southern margin of the great Carboniferous area of New Brunswick which in the eastern part of the province, stretches from Chaleur bay on the north to the head of the Bay of Fundy on the south, a distance of about 150 miles (240 km.). The Carboniferous area of New Brunswick extends over approximately 10,000 square miles (26,000 sq. km.) and over by far the greater part of this large area the strata are nearly flat-lying and, customarily, are considered to be of Millstone Grit age. Along the southern margin of the area older divisions of the Carboniferous are exposed and, in places, are folded and faulted.

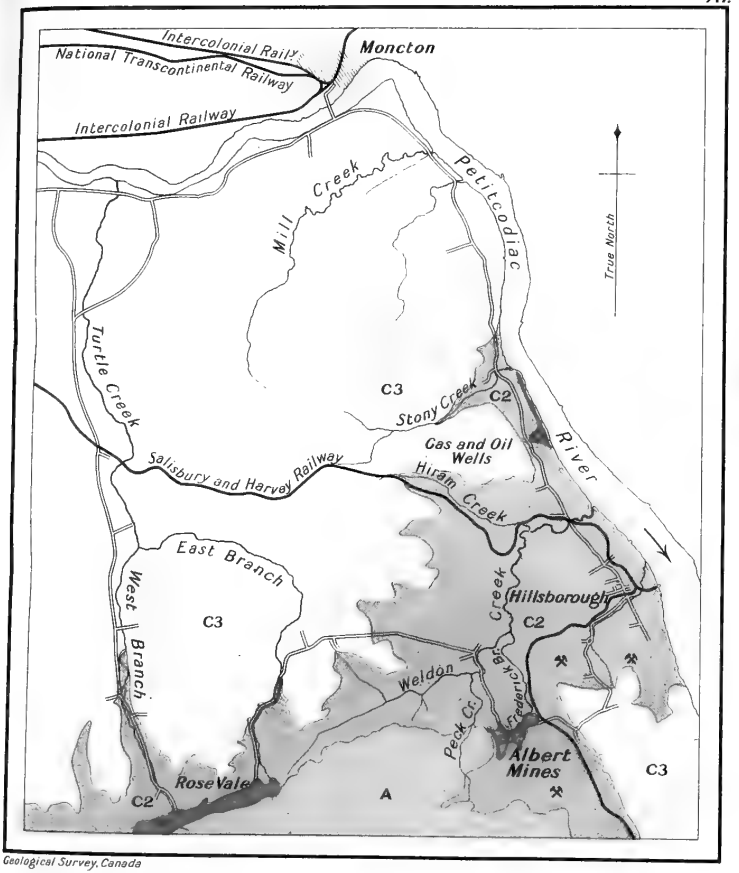
*See Map—Moncton—Albert Mines.

The city of Moncton lies about 20 miles (30 km.) north of the eastern end of Caledonia mountain, an upland area largely underlain by pre-Carboniferous igneous and sedimentary rocks that extend southwesterly along the Bay of Fundy coast and mark the southern boundary of the Carboniferous area. Over considerable portions of Caledonia mountain, the surface is comparatively level with a general altitude of above 1,000 feet (300 m.). In the vicinity of Moncton, the country is low and gently rolling, and in only a few places rises higher than 200 to 300 feet (60 m. to 90 m.) above the sea. The lowland area about Moncton and the upland area of Caledonia mountain merge into one another, though when the country is viewed from a vantage point, there is every appearance of a sharp boundary between the two areas.

Moncton is situated near the southern margin of the area of grey and red sandstones and shales of Millstone Grit age which stretches westward and northward like a great mantle over a large portion of New Brunswick. The Millstone Grit beds extend southward past Moncton over the area of gradually rising country which merges into the upland of Caledonia mountain. Along the borders of Caledonia mountain and stretching northward and eastward from it, are deep-set valleys and in and along these valleys are exposed older Carboniferous measures outcropping from beneath the Millstone Grit beds which on the north crown the ridges and higher spurs that project finger-like towards Caledonia mountain. The underlying, older Carboniferous strata include representatives of the Carboniferous Limestone series, and of the Albert series which have been correlated with the Horton series of Nova Scotia, and are considered to be of very early Carboniferous age.

The Millstone Grit strata lie horizontally or with very low angles of dip; in places the underlying Carboniferous strata are as little disturbed, while in other places in the same district they are faulted and tilted at high angles. There is thus abundant evidence of a pronounced unconformity between the Millstone Grit and the underlying divisions of the Carboniferous, and there is also direct evidence of the existence of unconformities between some of the older divisions.

The Millstone Grit beds and the underlying Carboniferous formations extend southward around the eastern end of



Geological Survey, Canada

Moncton-Albert Mines

Miles
0 1 2 3 4 5

Kilometres
0 1 2 3 4 5 6 7

Legend

Carboniferous
- C3 — Millstone grit
- C2 — Intermediate group
- Albert series

A — Pre-Carboniferous

⚒ — Gypsum Quarry

the pre-Carboniferous area of Caledonia mountain and eastward into Nova Scotia where the New Brunswick Carboniferous area merges into that of the Carboniferous basin, the general characters of which are so well displayed in the Joggins section. In the relatively elevated country which extends eastward from the end of the Caledonia upland, the Millstone Grit strata gradually lose the nearly horizontal attitude so characteristic of their general development over so large a portion of New Brunswick, and in places are inclined at angles of from 30° to 45° and presumably traversed by faults. On the other hand, the underlying Carboniferous measures in their extension southward and eastward into Nova Scotia, are less and less folded and faulted. As a result of these progressive changes, the evidences of the unconformities in the Carboniferous section so plainly displayed to the south of Moncton, largely disappear in the Joggins section and in other districts of Nova Scotia, and the Carboniferous series in such places appears to have always been folded and otherwise deformed as a unit.

The districts bordering Caledonia mountain and extending eastward along the continuation of the axis of this upland, are, as indicated above, favourable places in which to determine and fix some of the revolutionary periods of Carboniferous time. Unfortunately, however, this has not yet been accomplished. On the accompanying geological sketch map of the district lying immediately south of Moncton and east of Petitcodiac river, the Carboniferous strata have been provisionally mapped in three divisions, namely,—Millstone Grit, Intermediate group and Albert series. It is not improbable that in the Intermediate group are placed certain measures that should be classed with the Millstone Grit, and others that should have been assigned to the Albert series.

In the general district to the south of Moncton, outlined on the accompanying map, there is a very distinctive division of the Millstone Grit consisting of a quartz conglomerate overlain by a quartzose sandstone. Both types of rock are light coloured, weathering yellow. The conglomerate is usually crowded with smooth, rounded pebbles of white and variously tinted quartz lying in a sandy, in part calcareous, base. This conglomerate with its distinctive characters, and the overlying sandstones, occur in neighbouring districts and the same conglomerate, or a

very similar one, has been described as being present in many places over the wide extent of the Carboniferous area of the Maritime Provinces.

In the vicinity of Hillsborough and Albert Mines, these light coloured conglomerates and sandstones are the youngest Carboniferous strata present; the areas occupied by them are those which on the accompanying map, have been coloured as being underlain by the Millstone Grit and over these areas the strata are horizontal or only very gently inclined. Northward of the vaguely defined boundary of these pale coloured, quartzose sandstones and conglomerates, the low country towards Moncton is floored by nearly horizontal reddish sandstones, shales and red, argillaceous limestones. In a few places the pale coloured, Millstone Grit sandstone and conglomerate outcrop and in such places appear to conformably overlie or to be interbedded with the red strata which have customarily been assigned to the Millstone Grit. Along the southern boundary of the main area of the pale coloured Millstone Grit strata as defined on the accompanying map, measures outcrop from beneath these distinctive beds which have been placed in the so-called Intermediate group but which probably in part belong to the Millstone Grit group. Such strata, for instance occur in the valley of Stony creek and there consist of quartz conglomerate, coarse and fine, light-coloured sandstone, and red and green argillaceous and calcareous shales.

The greatest thickness of the pale coloured, Millstone Grit conglomerate and sandstone does not exceed a few hundred feet. The reddish, underlying strata presumed to belong to the same group, may be somewhat thicker but the strata of the whole Millstone Grit group as developed in the neighborhood of Moncton and Hillborough, does not anywhere attain a thickness comparable with that found in various districts of Nova Scotia. In general, the Millstone Grit strata appear to form a comparatively thin mantle resting on and covering the variously disturbed and eroded members of the older divisions of the Carboniferous. In places, however, in this and adjoining districts, the Millstone Grit beds appear to conformably succeed different divisions of the earlier groups without any plainly marked indications of the unconformity that is known to exist below the horizon of the Millstone Grit.

The strata of the area of the so-called Intermediate group indicated on the accompanying map, may, as already stated belong in part to the Millstone Grit. What appears to be the lowest member of the Intermediate group holds as a characteristic member a very considerable thickness of red strata that in composition vary from an argillite to a limestone, are generally of a bright, brick-red colour but in many places are splotched or banded with green. With these rocks are associated reddish sandstones and conglomerates and, perhaps, grey and dark grey limestones and siliceous beds.

A second division of the Intermediate group, younger than the above, consists of coarse, heavily bedded conglomerates and sandstones overlain by dark grey thinly bedded limestones which in places, as near Hillsborough, are capped by a considerable volume of anhydrite and gypsum.

A third, still younger member of the Intermediate group is made up essentially of red conglomerates and sandstones succeeded by red and green argillites and argillaceous limestones.

The total thickness of these three divisions of the "Intermediate group" must surpass several thousand feet. The strata in places lie with high angles of dip; in other localities they are nearly horizontal, and in such cases different divisions may appear to succeed one another conformably, as if without a break, although there is indirect evidence to indicate that prior to the deposition of each succeeding division, the strata of the immediately underlying division had been eroded in no inconsiderable degree.

The Albert series is the oldest of the Carboniferous system in the district. This series consists of a group of thinly bedded, usually dark coloured slates, calcareous slates, limestones and sandstones. Interbedded with these, whether or not at more than one general horizon has not yet been determined, are slates relatively rich in hydrocarbons and of a distinctive appearance. These, so-called, oil-shales when retorted yield varying amounts of crude oil and nitrogen—about 27 to 56 imperial gallons of crude oil, and about 30 to 112 pounds of ammonium sulphate per ton [**3**, part I, p. 17]. In these oil shales and associated beds, in places, are numerous remains of fishes of the genus Palaeoniscus. From the Albert series as developed in the

neighborhood of Albert Mines, the following species have been described. [**6**].

Rhadinichthys alberti.
Elonichthys browni.
E. elegantulus.
E. ellsi (Lambe).

Though by some geologists it has been claimed that the Albert series and the correlated Horton series of Nova Scotia are of Devonian age yet the palæontological evidence indicates that they are of Carboniferous age as pointed out by Lambe [**6**] in the following words.

"There is a great similarity between the fishes of Albert mine.....and those described by Dr. Ramsay Traquair from the Calciferous Sandstone series of Scotland; they belong to the same genera, but differ as to species. The genera of Palaeoniscidae; *Rhadinichthys*, *Elonichthys*, and *Canobius*.....have been considered to be typical of the Carboniferous age".

From the Albert series have been recovered several species of plants. These include "*Aneimites acadiens* and *Lepidodendron corrugatum*, the characteristic and omnipresent species of the Horton group, to which the Albert series belongs."*

The strata of the Albert series are exposed in the vicinity of Albert Mines and at other localities to the east and west. In some of these places the strata are comparatively undisturbed and lie with low angles of dip ranging in value between 5° and 30°. In the Albert Mines area, however, the strata form a rather tightly compressed anticlinal fold, and in places are vertical. At this locality they are unconformably overlain by division two of the Intermediate group.

The Albert series is of especial importance since it is from the sandstone members of this series that the petroleum and natural gas of the Stony Creek field (situated a few miles north of Hillsborough) are derived. The Albert series, with the same general characters as at Albert Mines, is exposed over a few detached areas extending east from Albert Mines for about 15 miles (25 km.). The same strata outcrop at intervals for about 25 miles (40 km.) to the west of Albert Mines and there occur along the northern slopes of Caledonia mountain. The Albert series has been

*From personal communication from David White, U. S. G. S., Washington, D. C.

traced still further westward and the late R. W. Ells has recorded his belief [**3,** part II, pp. 10-21], that the Albert series progressively changes in character as followed in a westerly direction, and that near St. John, on Kennebecasis island it is represented by coarse grey sandstones.

The oldest strata, in the district to the south of Moncton, are those forming Caledonia mountain. Over this upland area, the rocks are largely of igneous origin, and at many localities have a schistose structure. The original rock types appear to have been mainly volcanic varieties, both massive and fragmental, and both acid and basic. Plutonic rocks—granite, diorite, etc.—form large bodies in the complex, and true sediments—slates, crystalline limestones, etc.—have been noted at various places. The general assemblage is of pre-Carboniferous age, for most of the rock varieties have furnished pebbles and boulders to the Carboniferous strata. Presumably the greater part of the rock complex of Caledonia mountain is of Pre-Cambrian age but in its western extension towards St. John city, Cambrian rocks and possibly younger strata are involved.

DETAILED DESCRIPTION.

MONCTON TO STONY CREEK OIL FIELD.

Along the highway leading from Moncton southward along the west side of Petitcodiac river to the Stony Creek oil field, there are few outcrops for a number of miles. On the south bank of the Petitcodiac, a short distance below the highway bridge crossing the river at Moncton, red argillite and argillaceous sandstone are exposed at low water. These beds are assumed to belong to the Millstone Grit group and to occur at a horizon below the light coloured quartzose sandstones and conglomerates so widely displayed over the country to the south.

About 3 miles (4·8 km.) south from the bridge at Moncton, the road on the west side of Petitcodiac river crosses Mill Creek. In the bank of the stream, just above the road crossing, is an exposure of nearly horizontal, light coloured sandstone resembling the strata of the higher horizon of the Millstone Grit developed farther south. In the bed of this stream for a considerable distance inland, red argillites, sandstones, and fine grits with grey beds of

the same rocks, outcrop with nearly horizontal attitudes. These measures presumably also belong to the lower division of the Millstone Grit.

No further exposures occur along the river or the road for some distance. About 1 mile (1·6 km.) beyond the crossing of Mill Creek, the road swings away from the shore of the river and runs on the side of a ridge sloping somewhat steeply to the river. This ridge is presumably underlain by the higher division of the Millstone Grit though no rocks outcrop.

On the shore opposite a point on the road about 1 mile (1·6 km.) south of the junction with a branch road leading inland, exposures commence and continue to occur along the shore to within a short distance of the mouth of Stony creek. The most northerly exposures are of pale coloured quartzose sandstones belonging to the upper division of the Millstone Grit. The strata dip to the south at a very low angle. Farther south the strata are horizontal and beyond this, dip at very low angles to the north. Approaching Stony creek, the quartzose conglomerate is brought to the surface by reason of the gentle northward dip and in the cliff faces along this part of the shore, the Millstone Grit conglomerate may be seen to be underlain by about 30 feet (9 m.) of red argillite reposing on red conglomerate. All the strata appear to be conformable and possibly belong to the Millstone Grit group. The boundary between the light coloured strata above and the red beds below, crosses the shore road where the steep descent into the valley of Stony Creek is commenced. This boundary line approximately follows a contour line and swings up the deep valley of Stony creek and returns towards the river higher on the slopes of the ridge lying south of Stony creek. The light coloured strata evidently lie on the northern limb of a very low anticlinal fold or flattened dome.

Where the shore road crosses Stony creek, there are, in the steep south bank of the stream valley, exposures of nearly horizontal, light coloured sandstones and conglomerates. Up the valley of Stony creek, these measures are overlain by green and red banded argillites and argillaceous limestone.

South of the crossing of Stony creek, the shore road enters what may be termed the Stony Creek oil and gas field. The wells are scattered over the top and eastern face of the high ridge fronting on the river.

STONY CREEK OIL AND GAS FIELD.

The present developments of the Stony Creek field are confined to an area about 2 miles (3·2 km.) long by 1½ miles (2·4 km.) broad, fronting on the west bank of Petitcodiac river and lying between Stony creek on the north and Weldon creek on the south. Between the two creeks the land rises rather rapidly from the level of the tidal river to an altitude of 460 feet (140 m.). Of the 23 wells drilled by the Maritime Oilfields Company, 4 are on the steep east front of the hill and the remaining 19 are scattered over the top of the hill.

Along the river front, strata of the Albert series are visible at low water over a stretch of about 2 miles (3·2 km.). At the north end of the section they are overlain by coarse, red conglomerate; proceeding southward, at the first exposures they lie nearly horizontally, beyond this they dip in various directions between south and west, at angles of 10° to 20°. The measures consist of thin-bedded limestones and dark shales with sandstone beds which in places are impregnated with hydro-carbons. The measures apparently lie on the crown of an anticline but there are indications that in places the strata are crumpled and faulted.

The lower slopes of the ridge facing the river to the east and the valley of Weldon creek to the south, are occupied mainly by nearly horizontal coarse red conglomerates and sandstones with some shales. These measures are conformably overlain by the quartz conglomerate and over this, by the light-coloured sandstone of the Millstone Grit. Possibly the lower, red strata belong to the Millstone Grit, but it may yet be proved that they are considerably older. On the north side of the ridge along the valley of Stony creek, the measures underlying the pale-coloured Millstone Grit beds consist of red and green shales, and sandstones, with beds of grey sandstone, quartzose conglomerate, etc. Thus the Albert series outcropping along the eastern base of the hill extends westward under it, as shown by the borings, and is overlain by red strata capped by grey beds. The Albert series is of very early Carboniferous age, the grey beds of mid-Carboniferous age. The exposures indicate, in general, that the measures of all the divisions have relatively gentle dips.

The wells stand at elevations varying between 250 feet and 460 feet above sea-level, and in depth they range from

1,200 to 2,060 feet (365 to 628 m.). After passing through a thickness of overlying formations usually amounting to about 350 feet (107 m.), they enter the Albert series, of which a maximum thickness of 1,800 feet (548 m.) has been penetrated without encountering any signs indicating the approach of the base of the formation.

The strata of the Albert series, as found in the various wells, consist mainly of thinly-bedded, shaly beds, usually black or dark green in colour and varying in composition from argillite to limestone. Besides the shaly strata, fine-grained quartzose sandstones are comparatively common, the number of individual sandstone beds in a single well varying between 3 and 15. In thickness the individual sandstone beds vary from a few feet to 100 feet (30 m.) or more. There is a rather general tendency for the sandstone beds to occur in groups, in a number of instances three such groups separated by intervals of 150 to 350 feet of shales (45 to 106 m.) being encountered in a single well. The aggregate thickness of a single group of sandstones may rise to 180 feet (55 m.), but more often lies between 3 and 90 feet (9 and 27 m.). The individual beds of a group of sandstones may be separated by shaly layers varying in thickness all the way from a few feet to 30 feet (9 m.) or more.

Though slight traces of oil or gas have been found in the shaly beds and, in one instance, in strata overlying the Albert series, the oil and gas are confined, practically, to the sandstone beds in the Albert series. In the case of one well which the drillers recorded as apparently passing through disturbed, broken strata, practically all the sandstones are free from oil or gas. In the producing wells, a small number of sandstone beds do not afford any trace of oil or gas. Usually the number of such dry beds is small in comparison with the total number of sandstone beds in a well; and the dry beds, as a rule, occur towards the top of the well, but such beds are also recorded as occurring beneath others with showings of oil or gas. Usually by far the greater number of the sandstone beds are recorded as at least showing oil or indicating the presence of gas, and in some of the wells, sandstone beds of two different horizons yield large volumes of gas.

In the case of about one-half of the number of the wells, all the sandstone beds (except such as are dry) of each well are recorded on the logs as being either all oil sands or all

gas sands. In the remaining cases, oil and gas sands irregularly alternate or they occur in two groups of which, in some wells, the oil sands form the higher group while in others the gas sands form the higher groups.

In two wells, strong flows of salt water were recorded. In one case the salt water was struck near the bottom of the well, being first met in a 12-foot (3·6 m.) sandstone bed lying 68 feet (20·7 m.) below an oil sand that, with other immediately overlying sands, yielded oil at the rate of 5 barrels per day. In the second instance, after having passed through two sands, both giving indications of oil, and one giving a small show of gas, a salt water sand was struck at a depth of about 810 feet (247 m.). This well was continued to a depth of 1,250 feet (380 m.), and in the additional distance of 440 feet (134 m.) passed through four beds of sandstone with an aggregate thickness of 245 feet (74·5 m.), but which were barren of oil or gas except in the case of the lowest bed which was said to give a "show of gas".

From seven of the wells the total calculated yield of gas, as derived from measurements made with a Pitot tube, was nearly 4,000,000 cubic feet per day, the closed pressure of the individual wells varying from 20 to 200 pounds per square inch. From twelve other wells, varying results were obtained. One well had a closed pressure of 525 pounds, rising in three days time to 610 pounds, and an estimated flow of 3,695,000 cubic feet per day; a second had a closed pressure of 475 pounds and an estimated flow of 8,893,000 cubic feet per day; and a third had a closed pressure of 560 pounds with an estimated capacity of 6,417,000 cubic feet per day. In these three cases, the volume was estimated from observing the rate of rise of pressure at one minute intervals. As regards oil, in the case of one well, 60 barrels accumulated in 20 hours; from another after an interval of 7 days, 87 barrels were pumped; while a third gave an estimated yield of 40 barrels in 25 hours. The above figures have been taken from records of the Maritime Oilfields Company who are developing the field.

STONY CREEK OIL FIELD TO HILLSBOROUGH GYPSUM QUARRIES.

Leaving the Stony Creek oil field, the highway descends the long slope to the valley of Weldon creek, and ascends and crosses the low ridge to the south, on which stands Hillsborough. The strata outcropping on the southern slopes of the ridge facing Weldon creek valley, are red conglomerates with interbedded red shales and sandstones. On the higher slopes, these measures are nearly horizontal, lower down on the valley side they dip both southward and westward at angles of 20° to 50°. Similar measures outcrop in the valley of Weldon creek dipping to the north, though where the highway crosses the creek near its mouth, the strata are nearly horizontal or dip at low angles to the south. Weldon creek valley apparently marks a synclinal axis in the red series and confirms the impression that the general structure of the Stony Creek oil field is anticlinal.

The low, broad ridge on which Hillsborough stands is underlain by red conglomerates with sandstones and shales, forming a general assemblage very similar to that developed in Weldon creek valley. The strata are folded along east and west axes, in places the angles of dip are high—60° to 70°— and presumably the measures are traversed by faults.

The ridge on which Hillsborough stands is bounded on the south by the valley of Quarry creek, which heads to the west in the gypsum quarries. A road leads up this valley to the quarries; the main road continues southward parallel with the river. Along the main or river road there are a few exposures of red conglomerate and the same strata, lying nearly horizontal, are exposed on the eastern slopes of the ridge rising to the south. In this ridge the red conglomerate is directly overlain by grey limestone beds which on the summit of the ridge are capped by gypsum beds. Farther south, apparently the same red conglomerate beds outcrop along the river bank, dipping gently to the south. These red conglomerates outcrop in the steep, cliff-face of Hopewell cape and are there overlain by about 100 feet (30 m.) of red sandstones, above which come 30 feet (9 m.) of red and grey shales capped by heavy beds of grey quartzose conglomerate and sandstone belonging to the Millstone Grit. All the strata appear

conformable and the general succession is very similar to that in the cliffs along the river above Stony creek, 12 miles (19 km.) to the north. The absence of the limestone and gypsum in the cliffs of Hopewell cape and their presence elsewhere intervening between the red conglomerate and the grey strata of the Millstone Grit, is presumptive evidence of the existence of an erosion plane beneath the Millstone Grit. Elsewhere in the general district there is evidence that this erosion was of a very pronounced character; that prior to Millstone Grit time, the older Carboniferous strata were carved into pronounced valleys and during the Millstone Grit period these valleys were filled with reddish sandstones and shales, while over all was laid a mantle of the grey quartzose conglomerates and sandstones.

On both sides of the valley of Quarry creek, along which runs the road leading to the gypsum quarries, are exposures of red conglomerate. The conglomerate strata of the ridge on the south side dip gently to the south and are overlain by grey limestone. The red conglomerate and the limestone beds are exposed on the side of the creek at the northern entrance to the gypsum quarries. Similar limestones outcrop to the west on the northern and western sides of the area of gypsum, and in general fashion, the dips indicate that the gypsum occurs towards the centre of a very shallow syncline probably traversed by a north and south fault situated toward the western edge of the area. On the south the gypsum area is bounded by a high ridge over whose summit the grey Millstone Grit strata outcrop, while between these and the gypsum beds, intervene red sandstones and conglomerates with a maximum thickness of probably not more than 100 feet (30 m.).

THE HILLSBOROUGH GYPSUM DEPOSIT.

(H. E. KRAMM.)

The limestone upon which the gypsum and anhydrite beds rest, have a thickness of approximately 40 feet (12 m.). The gypsum and anhydrite beds have a thickness of about 250 feet (76 m.). The gypsum is the massive crystalline variety. It is usually slightly coloured by some impurities such as oxide of iron, calcium carbonate and organic matter, but absolutely pure gypsum, the variety alabaster, is also found at Hillsborough and mined. Crystals of selenite

imbedded in the solid crystalline gypsum are common near the surface of the deposit. Some of them are 3 to 4 inches (7·5 to 10 m.) in length and are perfectly terminated and easily separated. Satinspar, the fibrous variety, is rare at Hillsborough.

For the origin of the gypsum deposits of New Brunswick and Nova Scotia, Dawson proposed a conversion of calcareous beds by means of sulphuric acid, the acid being derived from igneous rocks and active volcanoes. This theory is an improbable one since there are ,at least in New Brunswick, no extensive bodies of igneous rocks present in the neighborhood of the gypsum deposits. Furthermore the gypsum often exhibits a series of approximately parallel lines of a darker color. These lines represent planes of easy cleavage and are thin films of calcium carbonate. Assuming an origin as proposed by Dawson it would indeed seem strange that sulphuric acid should convert practically the whole mass to gypsum and leave a series of films of calcium carbonate unattacked.

The field evidence obtained by the writer indicates a transformation of the anhydrite into gypsum. Evidence of this is especially abundant at Hillsborough. The gypsum rests upon a bottom of anhydrite and reaches a maximum thickness of perhaps 125 feet (38 m.). The hydration of the anhydrite can be observed in many places, taking place in either of two ways, namely:— (1) Hydration is uniform from the surface towards the centre of the mass and the increase in volume caused by the process breaks and shatters the outer layers. (2) Hydration starts along some crack or fissure which becomes filled by gypsum. The force exerted by the gypsum during its formation, causes the anhydrite to split into a network of fissures along which hydration proceeds and eventually converts the whole mass into gypsum.

It is, however, not likely that the calcium sulphate was originally deposited in the form of anhydrite. The physical chemistry of anhydrite has never been understood. Van't Hoff determined thermodynamically, that anhydrite is deposited in a saturated sodium chloride solution at 36° C. Actually, to the writer's knowledge, this has never been experimentally verified. The claims of geologists for the deposition of calcium sulphate as anhydrite are principally based upon the fact that anhydrite is found in nature, and upon the experiments of Van't Hoff. The first is an idea

which can be disputed; Van't Hoff's results, however, as to soluble anhydrite have been disproven by W. A. Davis* who showed that it is ordinary anhydrite that forms, and not, as Van't Hoff claimed, an anhydrite with entirely different physical properties. This puts the results as to anhydrite into a rather doubtful light. It is certain that anhydrite is not deposited in water at ordinary temperatures and under such conditions as exist at the present day, and it is not deposited at much greater temperature.

On the other hand, gypsum is easily dehydrated at low temperatures. It is much more probable that the calcium sulphate deposits were deposited in the form of gypsum, and that the pressure caused by the enormous layers of sediments which were subsequently piled on top of it partly or wholly dehydrated it. The dehydration of the gypsum is observable at the present day.

ALBERT MINES.

From the western head of the gypsum quarries, a road leads to the valley of Frederick brook and to the area of the Albert series at Albert Mines. Along this road, on the brow of the slope to the valley of Frederick brook, are exposures of grey limestone dipping eastward at angles of 60° to nearly 90°; in places the strata are contorted. Presumably the strata are traversed by a fault. Along the road farther south where it parallels the railway traversing Frederick brook valley, is a low cliff of coarse conglomerate dipping to the east at a low angle. A short distance east, the conglomerate is overlain by the grey limestone, above the limestone occurs red sandstones overlain by the grey beds of the Millstone Grit. No gypsum is known to be present and though it may have been cut out by a fault, it is more probable that the gypsum was removed by erosion prior to the deposition of the Millstone Grit.

The conglomerate exposed in the cliff at the roadside, and in a small cutting along the railway and elsewhere in the neighborhood, is very dark in colour due to the presence of hydro-carbons with which the rock is impregnated. The conglomerate is the ordinary red conglomerate which

*Jour. Soc. Chem. Ind. Vol. XXVI, 1907, p. 727.

elsewhere occurs underlying the limestone and gypsum beds.

The low area of the valley of the western branches of Frederick brook which extends westward from opposite the cliff of conglomerate on the road side, is occupied by strata of the Albert series. The rising ground on all four sides is underlain by the gently dipping red conglomerate which near the area of the Albert series is, in many places, of a dark grey colour from the presence of hydro-carbons. Though no fragments of the Albert series have been found in the conglomerate of the surrounding area, it seems impossible to escape the conclusion that the surrounding, gently dipping conglomerates unconformably overlie the highly disturbed strata of the Albert series.

The Albert series at Albert Mines outcrops over an area about $1\frac{1}{4}$ miles (2 km.) long in an east and west direction and having a variable width of from $\frac{1}{4}$ to $\frac{3}{4}$ miles (0·4 to 1·2 km.). The strata are comparatively well exposed in the eastern part of the area, along the various branches of Frederick brook. The measures, in general, dip to the south with angles varying from 15° to nearly 90°. On one branch of the brook the crown of an anticlinal fold is visible and it has generally been stated that the measures lie in an anticlinal fold whose axis strikes east and west. The strata as exposed consist chiefly of dark, thinly bedded shales, and thin beds of dark limestones. At certain horizons occur "oil-shales" heavily impregnated with hydro-carbons. Two main varieties of oil-shales are present. In the case of one variety —"curly shales"— the rock is compact, splintery, and the bedding planes in many instances are minutely crenulated. In the case of the second variety—"paper shales"— the beds split into thin, slightly flexible sheets.

The mining operations at one time carried on in this area and the extent of which is indicated by the large dumps, were conducted for the purpose of winning the substance albertite, fragments of which are abundant in the mine dumps. Albertite, by many authorities classed with asphalt and supposed to be a solidified form of petroleum, is a black substance, having a conchoidal fracture and a hardness of about 2 on the ordinary scale of hardness. It is easily fusible and readily ignites in an ordinary flame. It is essentially composed of hydrogen and carbon with about 3 per cent of nitrogen, 2 per cent of

oxygen, and a trace of sulphur. The mineral occurs filling fissures, usually narrow, not only in the Albert series but in younger Carboniferous strata. Most of the reported occurrences of such veins have been within a radius of a few miles from Albert Mines. The only large vein ever discovered was that occurring at Albert Mines. This vein, it is said, was mined over a distance of about ½ mile (0·8 km.). and to a depth of 1,100 feet (330 m.) or more, beyond which it became too narrow to be profitably worked. The vein was nearly vertical and followed an almost straight course along the general direction of the anticlinal axis in the country rock, but varied in width up to 15 feet (4·5 m.) and sent apophyses into the adjoining strata.

Regarding the origin of the albertite, "oil-shales", and natural gas and petroleum occurring in the accompanying sandstones as developed in the Stony Creek oil fields, two general views have been held. On the one hand, it has been thought that the various hydro-carbons are of secondary origin, derived from sources outside of the Albert series. The second view is that the hydro-carbons are indigenous to the shales and that they have been derived from organic matter entombed in the sediments. This latter view of the origin of the hydro-carbons seems particularly applicable to the known facts in connexion with the Albert series.

BIBLIOGRAPHY.

1. Bailey, L. W., and Ells, R. W., Geol. Sur. Can., Report of Progress, 1876–77.
2. Dawson, W. J.....Acadian Geology.
3. Ells, R. W.....Dept. of Mines, Bituminous or Oil-Shales of New Brunswick and Nova Scotia, 1910.
4. Ells, S. C.....Geol. Surv. Can., Map 35A, 1911.
5. Kramm, H. E.....Geol. Surv. Can., Summary Report for 1911.
6. Lambe, L. M.....Geol. Surv. Can., Memoir No. 3, 1910.
7. Young, G. A.....Geol. Surv. Can., Summary Report for 1911.

ANNOTATED GUIDE.

MONCTON TO ST. JOHN.

(G. A. YOUNG.)

Miles and Kilometres.

0 m. 0 km. **Moncton**—Alt. 50 ft. (15·2 m.). The Intercolonial railway leaving Moncton, runs in a southwesterly direction up the valley of Petitcodiac river, crosses a low summit with an altitude of 167 feet (50·9 m.) and enters the valley of Kennebecasis river which flows in a southwest direction. The railway follows the valley of Kennebecasis river to the head of Kennebecasis bay, a long lake-expansion of St. John river. The railway, at this point leaves the waterway; farther on it again skirts the shore of the lake, and finally leaving it for a space of about 6 miles (9·6 km.) runs directly to St. John city, situated on the Bay of Fundy coast, at the mouth of St. John river.

Throughout the greater part of the distance from Moncton to St. John, the railway runs parallel with and from 5 to 10 miles (8 to 16 km.) north of the foot of Caledonia mountain. This upland area with a mean altitude of about 1,000 feet (300 m.) is composed chiefly of Pre-Cambrian rocks of igneous and sedimentary origin. This area of ancient strata extends along the coast to St. John city and beyond, but towards St. John and to the southwest, the country underlain by these rocks is much lower than is the case to the northeast. The Pre-Cambrian area as far southwest as St. John, is bordered on the northwest by Carboniferous measures and immediately along the border these belong to pre-Millstone Grit divisions. These Carboniferous measures for many miles southwest of Moncton, extend to the north and west to join the main Carboniferous area of New Brunswick. Farther to the southwest, however, the Carboniferous strata are confined to a long band-like area bounded on both sides by ridges of Pre-Cambrian beds.

89·2 m. 143·5 km. **St. John.**

ST. JOHN AND VICINITY.*

(G. A. Young.)

INTRODUCTION.

The neighbourhood of St. John city is of special geological interest since it includes a portion of the Cambrian basin which has furnished so much palæontological material to Doctor G. F. Matthew. In the immediate neighborhood also, occur the 'Fern Ledges' from which many plant remains have been recovered whose age has been variously assigned to the Silurian, Devonian, and Carboniferous.

In the neighborhood of St. John, the following formations and groups are developed.

Carboniferous..	Red Head formation.†	
	Mispeck formation	
	Little River group	Cordaite formation.
	Bloomsbury formation	Dadoxylon formation.
Cambrian and Ordovician..	St. John group.	
Pre-Cambrian..	Crystalline limestone, quartzite, schists, gneiss, granite, etc.	

The various groups of strata are exposed over elongated areas all trending northeastward parallel with the coast of the Bay of Fundy and with the axial lines of the more prominent physical features. The Pre-Cambrian rocks are developed over a wide zone stretching for more than 100 miles (160 km.) along or near the Bay of Fundy coast. The Cambrian measures are confined in the main, to an area almost completely encircled by the Pre-Cambrian strata and reaching for 30 miles (48 km.) northeastward from St. John city. Minor parallel basins of Cambrian beds lie to the northeast within the same general Pre-Cambrian region. The Little River group together with the immediately underlying and overlying formations, outcrops over an elongated area situated southeast of the St. John Cambrian basin.

* See Map,—St. John and Vicinity.

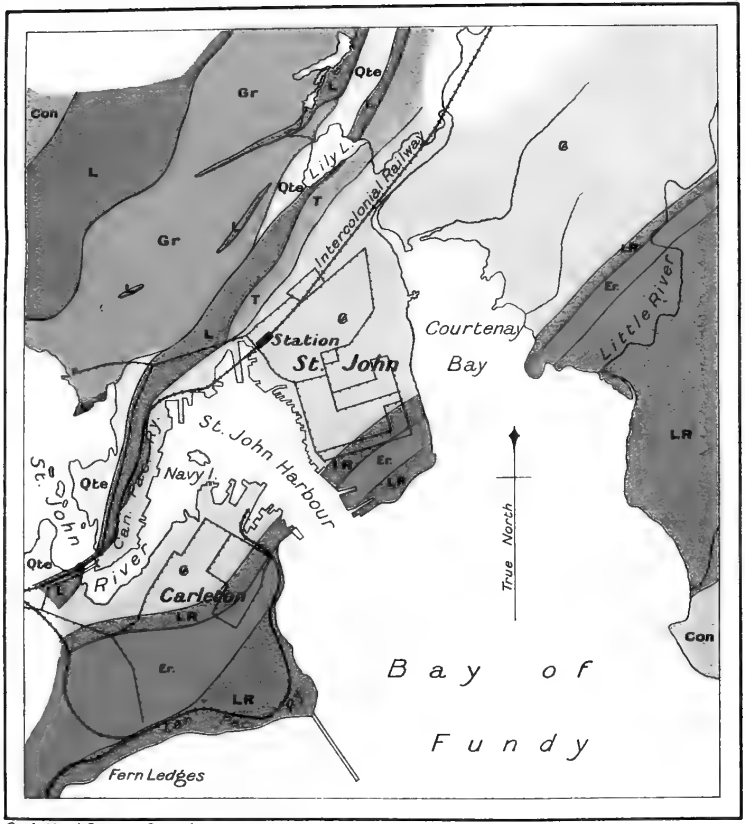
† The term, Red Head formation, is applied provisionally to certain strata at one time classed as Lower Carboniferous Conglomerate.

The details of the geological structures of the region are largely unknown. The Pre-Cambrian strata are presumably much faulted and folded. They have been intruded by large and small bodies of plutonic rocks. Different broad divisions of the Pre-Cambrian are developed along northeasterly trending axial lines and this mode of distribution doubtless indicates that the axes of folding and the strikes of the major faults are also parallel with the same general direction. The Cambrian and Carboniferous measures are also folded along northeasterly trending axes, but, whereas the Cambrian beds in places are tightly folded and overturned, the Carboniferous measures lie in open folds.

The *Pre-Cambrian* strata include both sedimentary and volcanic types probably belonging to groups of greatly differing ages. So far as we know, all have been intruded by plutonic masses varying in composition from gabbro to granite and not all of the same age. Possibly some of the plutonic rocks classed with the Pre-Cambrian may be of Palæozoic age and the same may be true of some of the volcanic rocks and even of some of the metamorphosed sediments. The Pre-Cambrian rocks have been divided into various divisions grouped under the terms Laurentian and Huronian. The Laurentian has been described as characteristically composed of crystalline limestone, quartzite, various schists, gneisses and granitic rocks. The Huronian has been defined as composed of great thicknesses of volcanic rocks including flows and pyroclastic types. The correlation of the volcanic strata with the Huronian as now defined, cannot be upheld. The correlation of the crystalline limestones and associated strata with the Laurentian is also of doubtful value.

The Pre-Cambrian rocks were greatly deformed, intruded by plutonic bodies and deeply eroded certainly earlier than Middle Cambrian time and in all probability earlier than Lower Cambrian time.

The *Cambrian* and *Ordovician* strata have been divided by Dr. Matthew into a number of divisions. These are presented in the following table based on one prepared by Matthew.



Geological Survey, Canada

St. John and **Vicinity**

Miles
0 1 2
Kilometres
0 1 2 3

Legend

- Con — **Carboniferous** Conglomerate
- LR — **Carboniferous(?)** Little River group
- Er — **Carboniferous(?)** Basic eruptives
- G — **Cambrian**

Pre-Cambrian:

- T — Trachyte
- L — Limestone series
- Qte — Quartzite series
- Gr — Granite, etc.

Street Railway

		Thickness.	
		Feet.	Metres.
Lower Ordovician.	Bretonian.	700	213
Cambrian.	Johannian.	750	228
	Acadian.	200	61
Basal Cambrian.	Etcheminian.	1,200	365
	Coldbrookian.	?	?

The Acadian, Johannian and Bretonian together compose the St. John group which consists largely of dark slates and very fine sandstones. Fossiliferous beds occur at many horizons.

The Etcheminian strata are shales, sandstones and conglomerates and fossils are not common in them. The Coldbrookian consists of various types of volcanic rocks.

Dr. Matthew regards the St. John group as being the equivalent of the whole of the Cambrian proper including the Lower Cambrian, Olenellus zone or its equivalent, and a part of the lower Ordovician. The Etcheminian, because in certain places it seems stratigraphically unconformable to the overlying Acadian and because it varies widely in thickness from place to place, is thought by Dr. Matthew to unconformably underlie the Cambrian proper. The Etcheminian is stated to contain a fauna of Cambrian aspect but of an earlier type than that customarily classed in other regions with the Olenellus zone. The Coldbrookian is described by the same author as formed of

volcanic flows and ejectementa older than the Etcheminian but still of Palæozoic age.

Dr. C. D. Walcott has presented arguments to show that the lowest division of the St. John group, the Acadian, is of Middle Cambrian age and belongs to the horizon of the Paradoxides fauna. By the same authority the Etcheminian is regarded as a phase of the Lower Cambrian. The variations in thickness of the Etcheminian from place to place are believed to be due to the presence of inequalities in the original floor of the Cambrian basin whereby in some places a thousand feet of Etcheminian strata were deposited, in others only a hundred feet or less, while in others the Middle Cambrian rests directly on the Pre-Cambrian. Evidence is given to show that the unconformities which in some places appear to exist between the Acadian and Etcheminian are, in some instances at least, due to faulting and minor movements attendant on the deformation of the Cambrian basin as a whole. The Coldbrookian is classed with the Pre-Cambrain as had been done by earlier writers.

The fine muds and sands of the St. John group and the coarser detrital material of the basal formation, the Etcheminian, were laid down in a sea having a very uneven bottom and which apparently existed continuously throughout the greater part of Cambrian time and on into the opening epochs of Ordovician time. It is assumed that this sea withdrew temporarily at least, during the Ordovician period. Elsewhere in the Maritime Provinces, marine Silurian, Devonian and Carboniferous measures are extensively developed but these if ever present in the immediate vicinity of St. John, were removed by erosion before mid-Carboniferous time and the Cambrian beds were faulted and closely folded along axial lines pursuing a general northeasterly course.

The *Bloomsbury*, *Dadoxylon* and *Cordaite* formations as developed in the neighborhood of St. John, succeed the Cambrian measures on the south and in places at least, are brought against them by faulting. The Dadoxylon and Cordaite formations together compose the Little River group (*)

On the eastern shores of Courtenay bay, these measures, including a band of igneous rocks, are developed on the

(*) On the map of St. John and vicinity, t e Bloomsbury division has been included under the term, Little River group.

northern limb of an open synclinal fold. The strata dip in a southeasterly direction at angles ranging from 65° in the north to 20 ° in the south towards the centre of the syncline. The beds are exposed at intervals only. Their thickness is approximately 4,000 feet (1,220 m.). In the lower portion of the series, at the faulted contact with the Cambrian, the beds for a few hundred feet in thickness are largely reddish conglomerates and sandstones with beds of greenish shale; these measures compose the Bloomsbury formation. They are succeeded by greyish and greenish sandstones and shales forming the Dadoxylon formation. Above them lie dark green shales and arenaceous shales with fewer sandy measures: these belong to the Cordaite formation. Towards the base of this general series, occurs a band of igneous rocks, largely diabase. These igneous rocks are probably, for the most part, contemporaneous extrusives though there is some evidence that they are in part at least, intrusives.

The lower divisions, including the igneous member, of the above general assemblage, occur also in the southern part of St. John city and along the shore to the west on the western side of St. John harbour. In the western extension at a locality known as the Fern Ledges and a short distance farther west at Duck Cove, the sedimentary beds have yielded to collectors a large number of plant species. First systematically described by J. W. Dawson, the plants were then considered to be Devonian. In more recent years, Dr. Matthew has contended that the containing beds are of Silurian age, while amongst others, Dr. White and Dr. Kidston have stated that the plants are of mid-Carboniferous, Pennsylvanian age. The stratigraphical evidence regarding the age of the Little River group is discussed in the immediately succeeding paragraphs.

The *Mispeck* formation consists largely of red conglomerates, sandstones and shales. They overlie the measures of the Little River group on the northern limb of the synclinal on Courtenay bay [**1**], and are repeated in a similar position on the southern limb of the same fold. The Mispeck beds in the Courtenay Bay district, appear to conformably succeed the strata of the Little River group but Dr. Matthew believes that the Mispeck is unconformable to the Little River group. This belief is founded on the phenomena exhibited at a locality a few miles to the

southwest of St. John where the Mispeck beds rest directly on Pre-Cambrian strata. In reference to this locality, Dr. Matthew states that since the Mispeck conglomerate there "contains rolled fragments of Silurian corals, the whole series below it to the horizon of these corals must have been denuded before or during its (the Mispeck) formation." The relations thus described may however, be explained as due to overlap and not as indicating the existence of an unconformity between the Mispeck and Little River group.*

The existence or non-existence of an unconformity between the Little River group and overlying Mispeck is an important point in the discussion of the age of the Little River measures to which belong the strata of the Fern Ledges. If an unconformity exists, it forms a link in the chain of stratigraphical evidence tending to place the horizon of the Little River group below the Carboniferous.

The *Red Head* formation† consists chiefly of coarse, red conglomerate and sandstone. These measures occur over a considerable area situated towards the centre of the synclinal basin of Little river and Mispeck strata exposed along the shore of Courtenay bay. The measures of the Red Head formation are not exposed in actual contact with the Mispeck beds. The relative areal distribution of the two series of strata, the marked difference in the direction of dip of the two formations, and the presence in the Red Head conglomerates of pebbles of sandstone and shale closely resembling rocks of the Mispeck formation, are all factors indicating that the Red Head beds are unconformably above the Mispeck measures. The physical characters of the strata of the Red Head formation also indicate that these measures are younger than the neighbouring beds of the Little River and Mispeck formations. The conglomerates and sandstones of the Red Head formation are only loosely cemented whereas the Mispeck and Little River beds, especially those of the latter formation, are more compact and in places at least, have suffered a slight amount of shearing not found to have affected the Red Head beds. It is remotely possible, however, that the Red Head formation does not overlie the Mispeck for along the eastern side of the area of Red Head beds,

*On the map of St. John and vicinity, the southern part of area represented as being occupied by Little River group is doubtless underlain by Mispeck strata.

†On the map of St. John and vicinity, the areas occupied by the Red Head formation are mapped as 'Carboniferous Conglomerate.'

are exposures of schists and gneissic rocks apparently altogether foreign in character to the strata of the Little River and Mispeck formations. It has been suggested that these schists and gneisses which occur towards the centre of the syncline of Mispeck and Little River strata, are deformed contemporaneous volcanic rocks. Possibly, however, they are of much greater age and it may be that the Red Head beds rest directly on them and not on the Mispeck formation

The red strata of the Red Head formation outcrop over a second considerable area lying northwest of St. John city. At this locality, the measures repose on Pre-Cambrian strata. They extend to the shores of Kennebecasis lake and lithologically similar strata outcrop on Kennebecasis island where they are conformably succeeded by a series of grey sandstones and shales with plant-bearing beds. The late Dr. Ells stated that the lower red strata on Kennebecasis island, the supposed equivalents of the Red Head formation, have been traced westward to the Maine boundary and there found to be the equivalents of the Perry formation. The Perry on the evidence of its contained plants has been assigned by Dr. David White to the Devonian. Both Dr. Ells and Dr. Matthew correlate the upper, grey plant-bearing beds of Kennebecasis island with the Albert series of New Brunswick and the Horton series of Nova Scotia. By Sir. J. W. Dawson, L. M. Lambe, and other paleontologists, the Albert and Horton series are considered to be of Lower Carboniferous age and older than the Windsor marine limestone.

Paleobotanical material has been collected by Mr. W. J. Wilson from the plant-bearing beds of the upper grey series on Kennebecasis island. The flora indicates that the containing measures are of early Carboniferous age and that, at least approximately, they are the equivalents of the Albert and Horton series

The measures occuring on Kennebecasis island, as the above evidence indicates, are of Lower Carboniferous age or possibly in part of upper Devonian age. If the red strata of Kennebecasis island are the equivalents of the Red Head formation which apparently unconformably overlies the Mispeck and which in turn overlies the Little River group, then it is manifest that the Little River group and the contained Fern Ledges, cannot be younger

than Devonian and that as far as the stratigraphical evidence indicates, may be even Silurian as contended by Dr. Matthew.

The plant-bearing Fern Ledges undoubtedly belong to the Little River group and according to various eminent authorities, the plants indicate in the strongest fashion possible that the strata are of mid-Carboniferous age. If this conclusion is correct then it must be conceded that either the Red Head beds are not younger than the Little River group, or if they are younger, that they are much younger than the lithologically similar strata occurring on Kennebecasis island.

CAMBRIAN AND PRE-CAMBRIAN SECTION, ST. JOHN CITY.*

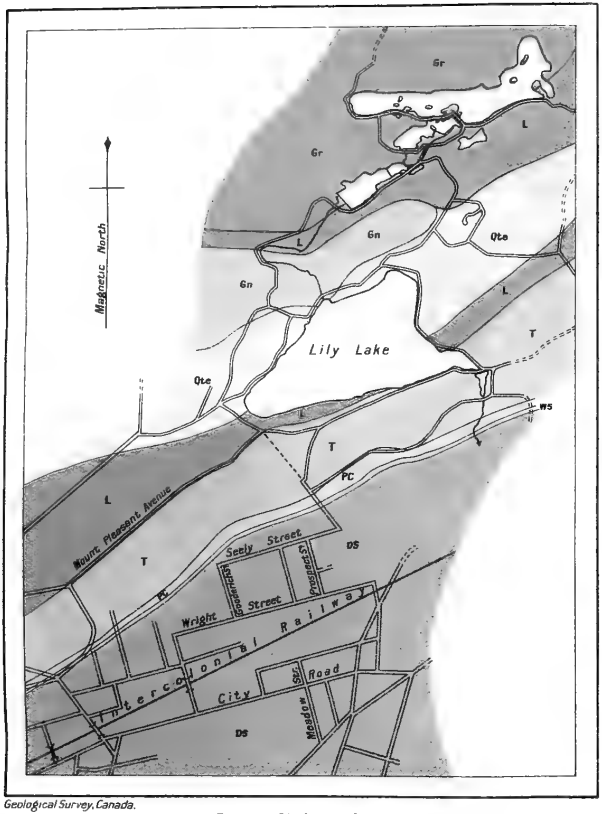
The Cambrian strata underlying St. John city are arranged in three synclinal folds whose axes strike approximately northeast. The folds, in general, are overturned and the strata are usually either vertical or dip steeply towards the south. The basin is traversed by a few major faults striking parallel with the course of the axes of folding.

The centre of the northern of the three synclines is indicated by a depression known as the "Valley" and in which lies the yard of the Intercolonial railway. The centre of the syncline is occupied by strata belonging to the Bretonian but the measures are largely concealed beneath the drift-covered floor of the Valley. The axis of the syncline passes on the south side of the depression, at the foot of a steep hill. On the opposite northern slope of the Valley are outcrops of Acadian, Johannian and Etcheminian strata forming the north limb of the syncline. Pre-Cambrian strata are exposed on the summit of the hill.

On Meadow street, just south of the junction of this street and City road, at the foot of the slope forming the southwest side of the Valley, a rock-cutting exposes strata belonging to the Bretonian, the highest of the Cambrian divisions. The measures are dark slates with many thin beds of hard, fine sandstone. At the beginning of the

* See Map,—Part of St. John City.

Geological Survey, Ca



Legend

Cambrian	DS	Dark slate and sandstone
	WS	White sandstone
	PC	Purple conglomerate, sandstone, etc.
Pre-Cambrian	T	Trachyte
	L	Limestone series
	Qte.	Quartzite series
	Gn.	Gneiss, schist, etc.
	Gr.	Granite

Geological Survey, Canada.

Part of St John City

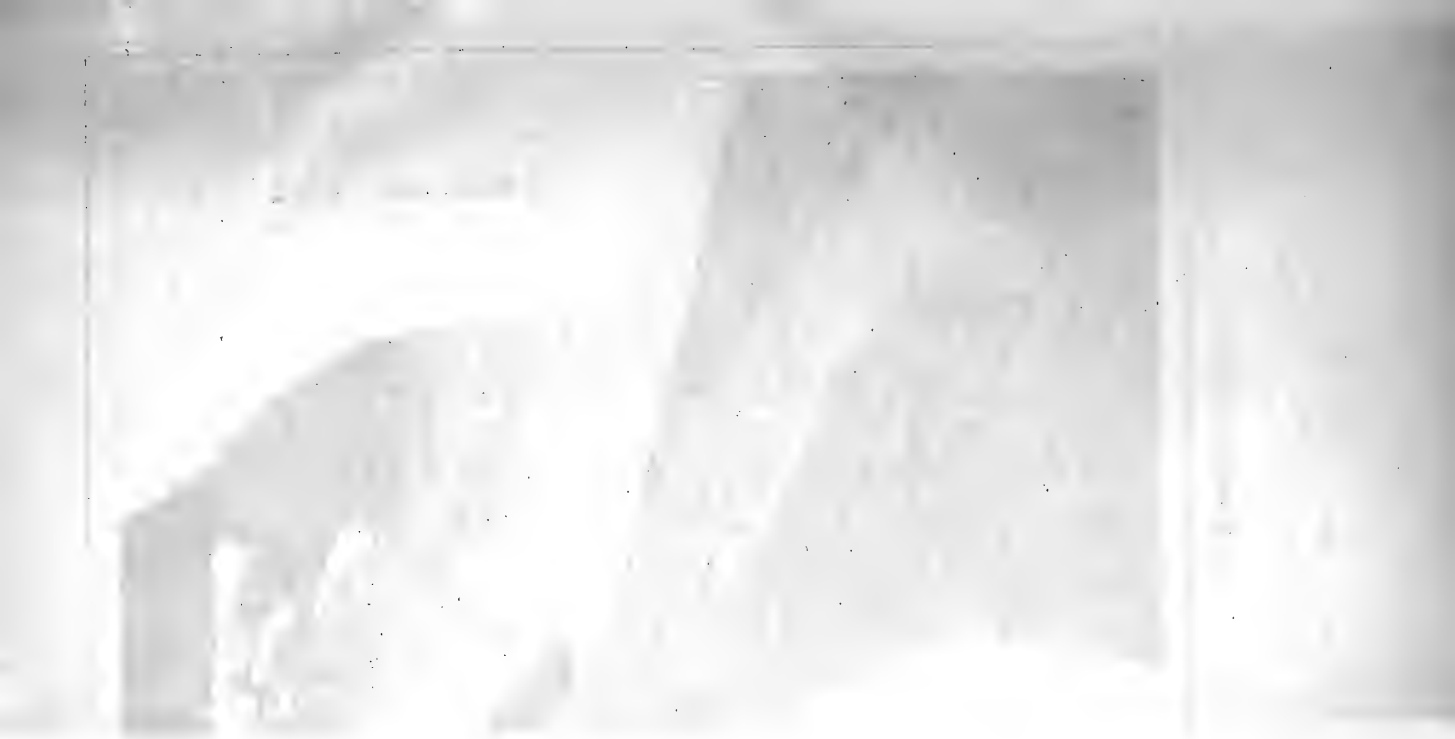
Feet

500 0 1000 2000

Metres

100 0 200 400 600

(Scale of map is approximate)



rock-cutting, the strata dip southerly at angles of about 45°. A few yards farther, they are twisted and torn, while just beyond this point, they again dip regularly at high angles to the south. The general attitude of the beds in the rock cutting suggests the presence of a synclinal axis and this may be the main synclinal axis of the northern syncline.

Fossils have not been found in these measures but in the corresponding strata in the next syncline to the south there have been found various characteristic Upper Cambrian forms including, *Peltura scarabeoides* and other trilobites of the genera Agnostus and Ctenopyge.

Along the south side of City road, are outcrops of the dark slates and fine sandstones of the Bretonian, striking almost parallel with the street and presumably situated on the northern limb of the synclinal fold and not far removed from the axial line. If this be so, the strata underlying the Valley and outcropping on the northern slopes of the Valley are arranged in descending order.

No strata outcrop along Stanley street which crosses the Valley at right angles to its course. Small outcrops of dark greenish or greyish slates with fine sandstone beds occur in rock cuttings along the railway tracks beneath the bridge on Stanley street and to the east and west of this bridge. These measures dip steeply to the south and strike at a very acute angle across the course of the railway. The concealed contact between these lighter coloured strata and the darker coloured shales of the Bretonian division probably crosses Stanley street not far north of the junction of this street and City road. The lighter coloured measures underlie the dark Bretonian slates and presumably belong to the Johannian division.

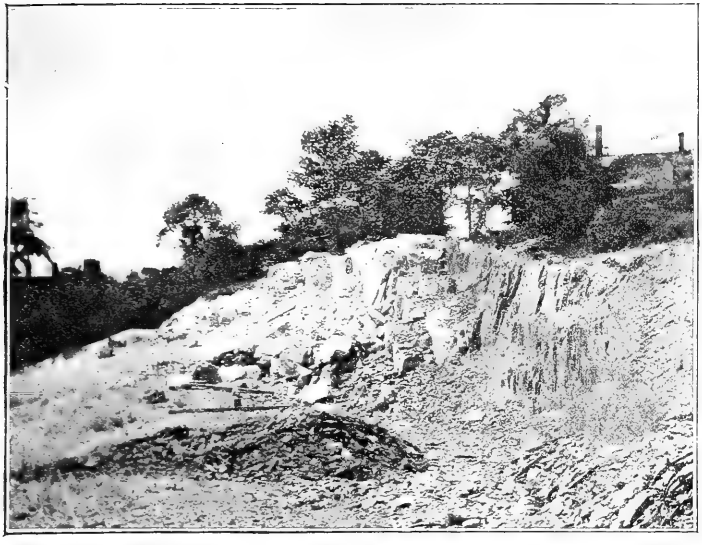
Though no strata outcrop on Stanley street north of the railway, there are a number of exposures of slate and sandstone along the streets and lanes immediately to the east. The measures there exposed belong in part to the concealed horizons that belong, stratigraphically, between the beds in the railway cuttings and the measures exposed on Wright street at the junction with Gooderich street. On Gooderich street and at the head of this street, a series of exposures forms a nearly continuous section of the Cambrian down to the contact with the Pre-Cambrian.

At the junction of Wright and Gooderich streets are exposures of dark greenish slates and many beds of fine sandstone. The strata dip southwards at angles of 70° to 80°. These measures belong to the Johannian division. Northward along Gooderich street, a progressive change takes place in the strata, the sandstone beds are thinner and fewer and the slates darker in colour. Towards the head of the street, the strata are mainly dark slates with thin, disrupted beds of fine sandstone. These measures belong to the Acadian division.

At the northwest corner of the junction of Seely and Wright streets are exposed remnants of fossiliferous shale, though this is not now a good collecting place. The common fossils still to be obtained are; *Paradoxides eteminicus*, *Ctenocephalus matthewi*, *Liostracus tener Linnarssonia transversa*, and *Acrothele matthewi*. Some years ago, members of the Protolenus fauna, including *Protolenus paradoxides*, were found by Mr. J. E. Narraway between the above fossiliferous layer and the white sandstone at the back of the quarry, but this outcrop is no longer available. The strata belong to the Acadian division and by Dr. Matthew are regarded as the equivalent of the Lower Cambrian of other regions. By Dr. Walcott and others, the fauna is held to be of Middle Cambrian age.

In the low rocky mound and small quarry at the head of Gooderich street, there are exposed to the north of, and therefore below the fossiliferous shales, about 70 feet (21 m.) of nearly vertical shales and sandstones. These are succeeded by a 20-foot bed of white, comparatively coarse sandstone. Beyond this distinctive sandstone bed are exposures of dark grey and purplish sandstones and shales with one thin bed of white sandstone separated from the main bed by about one foot of the dark rocks. A thickness of about 50 feet (15 m.) of the dark sandstones and shales is exposed. To the north, after a concealed interval of about 60 feet (18 m.), rises a low ridge of dense, green trachyte belonging to the Pre-Cambrian. The strata in general strike to the southwest and dip at very high angles to the southeast. In spite of local slips and warpings in the beds, the whole series appears conformable.

The massive bed of white sandstone marks the base of the Acadian. The dark grey and purple sandstones



Etcheminian at right, basal quartzite of Cambrian (centre) and Protolenus bed (left). Seely street, St. John, N.B.

Base of Etcheminian unconformably on the Pre-Cambrian, Park street, St. John, N.B

and shales represent the Etcheminian. The green trachyte belongs to the Coldbrookian.

The white sandstone is a constant feature at the same horizon over a great part of the whole Cambrian basin. By Dr. Matthew this bed is regarded as the base of the Lower Cambrian while by Dr. Walcott it is held to mark the base of the Middle Cambrian as the fauna of the immediately overlying beds indicates. Under this view the Etcheminian is of Lower Cambrian age. By Dr. Matthew the trachyte is considered to be an effusive flow closely associated as regards age with the overlying Etcheminian both of which formations are thought to be older than the Lower Cambrian or Olenellus zone.

Seely street follows a nearly due east course from the head of Gooderich street, almost parallel with the strike of the Cambrian (Acadian) measures. At the junction of Seely and Prospect streets, the strata are well exposed. The measures consist of dark slates alternating with harder beds usually less than one inch in thickness.

On the eastern side of the road leading north from the eastern end of Seely street, are exposures of nearly vertical, dark slates with thin beds of dark, fine grained sandstone. To the north of these beds, the white sandstone, the base of the Middle Cambrian, is exposed in a small ridge. The width of the outcrop along the roadside is about 40 feet (12 m.). Immediately overlying the white sandstone is a dark, coarse sandstone, while underlying it are dark greenish sandstones belonging to the Lower (?) Cambrian, Etcheminian division. The strata dip to the southeast at an angle of about 60°. The contact of the Etcheminian with the underlying volcanics of the Coldbrookian is not exposed along the roadside. The first exposures of the underlying volcanics is a few yards north of a branch road leading to the northeast.

The basal beds of the Cambrian are only imperfectly exposed along the roadside. The following section as measured by Dr. Walcott in the immediate neighborhood, indicates the general character of the strata. The measures are tabulated in descending order, that is, in the order in which they are exposed along the road from south to north.

Middle Cambrian;—

b. Greenish and dark shales and fine sandstones.....
a. Light grey, quartzitic sandstone 40-45 feet (12-14 m.)

Lower (?) Cambrian (Etcheminian);—

c. Reddish-purple and greenish shales and thin sandstones.....52 feet (15·8 m.)
b. Concealed (presumably shales and sandstones).....85 feet (26 m.)
a. Dark reddish conglomerates, sandstone and shale.....12 feet (3·6 m.)

Pre-Cambrian.—

The lowermost beds of the Etcheminian and the nature of the contact with the Coldbrookian (Pre-Cambrian) is indicated in a series of exposures along the branch road leading to the northeast. This road passes along the south side of a low rocky ridge of the dark green, fine-grained trachyte immediately underlying the Cambrian beds. The Pre-Cambrian volcanic rock in some of the exposures on the road side is reddish in colour and in places possesses an irregular, shale-like parting, apparently resulting from weathering. At some points, the igneous rock is less altered and is of a pale greenish colour. At several places are small exposures of fine greyish or slightly reddish conglomerate overlying decomposed trachyte and evidently mainly composed of detritus from the Pre-Cambrian volcanic.

The purple weathering, green volcanic rocks underlying the Cambrian forms a band striking to the northeast. This band where it is traversed by a path running northward to Mount Pleasant avenue is about 700 feet (215 m.) wide. Along the pathway outcrops are few but the rocks are well exposed on the ridges rising on both sides. The igneous rock in most places is quite uniform in appearance being a fine grained, almost dense trachyte with minute feldspar phenocrysts. In some places as along Mount Pleasant avenue where it skirts the shores of Lily lake, the rock has a fragmental structure and appears to be of tuffaceous origin. The occurrence of this fragmental variety suggests that the igneous rock as a whole is of effusive origin. The age of the rock is supposedly Pre-Cambrian since it

underlies and has furnished detrital material to the Cambrian beds and since nowhere in the general Cambrian basin have volcanic rocks been described as occurring interstratified with Cambrian measures.

The relations of the trachyte to the other Pre-Cambrian strata exposed over a very wide area to the north, is unknown. On the north side of the volcanic rock lies a band of crystalline limestone and the two rocks are in contact for a distance of at least two miles. The constancy of this feature considered in connexion with the nature of the volcanic rock, may be taken to indicate that the trachyte is of the same age as the limestone strata. No decisive evidence is available to indicate whether the igneous rock is stratigraphically above or below the limestone.

The band of crystalline limestone extends in a southwest-northeast direction for at least 4 miles (6·4 km.). At the end of the path traversing the band of trachyte, the contact between the volcanic and the crystalline limestone follows southwesterly along Mount Pleasant avenue. On the north side of this road are many exposures of white crystalline limestone traversed by broken and bent dykes or sills of diabase. To the northeast, the full width of the band of limestone is exposed on the eastern shores of Lily lake. In this neighborhood, the width of the crytalline limestone band is about 250 feet (76 m.). To the southwest, the band rapidly expands to a maximum width of about 950 feet (290 m.).

The character of the limestone measures is exhibited in a series of exposures along the road known as Lake Drive North which leads from Mount Pleasant avenue past the west end of Lily lake and along the shores of a group of smaller lakes to the north. Where this road crosses the band of crytalline limestone, the rocks at one point are flexed into a syncline and other indications of the deformation of the strata are present. The original bedding planes are indicated by variations in texture, colour, etc. The northern margin of the limestone band is marked by a zone of black rocks, partly slates, partly diabase.

Just beyond the first cross road on Lake Drive North, are exposures of dense, light coloured quartzite belonging to a band of such rocks having a width of about 800 feet (245 m.). This band of rocks forms the northwestern boundary of the limestone series for some distance both to the northeast and southwest, except where the quartzites

have been replaced by intrusive rocks. The quartzite and limestone presumably belong to the same series but it is not known whether the quartzite underlies or overlies the limestone.

The quartzites are exposed at intervals along Lake Drive North. At a series of exposures where this roadway rises over a low hill, the quartzites are comparatively coarse grained and are distinctly bedded, the strata being nearly vertical. The quartzites are exposed along the roadsides to the top of the rise but farther on, as the road descends to where a branch road runs east to the shores of Lily lake, decomposed gneissic rocks outcrop.

Gneissic rocks are exposed along the driveway from the point of junction of the branch road, northward to where the main road bends to the northeast beside a small stream. The gneisses are of medium to fine grain, are dark coloured, flecked and streaked with pink and are strikingly foliated. The rocks have the mineral composition of a biotite or hornblende granite and appear to be deformed granites. They occupy a narrow band-like area reaching a few hundred yards to the east but extending much farther to the west where they join a large area of granite. The relations of the gneissic rocks with the granite are unknown. Possibly the gneissic rocks have resulted from the local deformation of the granite.

The area of deformed granite is bounded on the north by a band of crytalline limestone which extends to the southwest as a long narrow band surrounded by granite. The limestone is bounded on the northwest side by granite and the roadway crosses and recrosses the line of contact. The limestone is of the same general character as the rock of the calcareous band striking across Lily lake. The granite occurring on the northwest side of the limestone band, is of medium grain, usually pink in colour and poor in coloured bisilicates which include both biotite and hornblende. In the neighborhood of the contact with the limestone, aplite dykes occur in the calcareous rocks.

The granite body shows slight variations in texture and composition from place to place. Small patches of foreign material occur. Small detached blocks of crystalline limestone also lie within the granitic rocks; one such block with a major diameter of about 35 feet occurs on the roadside towards the western end of the larger of the three lakes lying north of Lily lake. Along the road leading

northward from the end of the same lake, exposures of granite alternate with others of diorite, diabase, quartzite and various types of schists. Some of the diabase rocks cut the granite, but the diorite and various types of schists are probably all older than the granite.

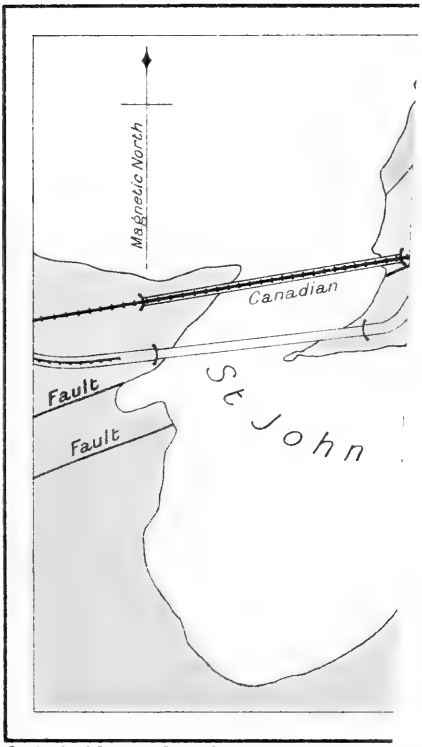
SUSPENSION BRIDGE.*

General Description.—At the locality known as Suspension bridge, the St. John river is spanned by two bridges—a railway bridge and a highway bridge. At this point the river is confined for about 300 feet (90 m.) to a gorge-like channel about 300 feet (90 m.) wide through which the waters rush in a southerly direction. Below this point the river channel suddenly widens, abruptly turns to the northeast, and follows this course for about one mile, to the head of St. John harbour. Above the constricted channel at the bridges, the river widens and about 500 yards (460 m.) farther up, again contracts. Above the second constriction, known as the "upper falls", the river widens to lake-like dimensions and after abruptly bending to the northwest continues with this character for many miles. A long arm of this lake extends to the northeast and this arm together with the northwesterly extending lake-like expansion of the St. John river is known as Kennebecasis lake.

The lake bottom is very irregular, with deep channels in which the water reaches depths of between 100 feet and 200 feet (30 m. to 60 m.). At the constriction known as the upper falls, the water is only about 25 feet (7·5 m.) deep. Below this point the channel is deep; even in the gorge-like portion at Suspension bridge, the water is 100 feet (30 m.) deep but at the exit from the short gorge at the lower falls, the water shoals to a depth of about 25 feet (7·5 m.). In the channel-way below Suspension bridge as far as Navy island at the head of St. John Harbour, the depth of the water varies between 30 feet and 100 feet (9 m. and 30 m.).

The waters of Kennebecasis lake, though in direct communication with the sea, always stand above mean tide level. In the spring of the year, the waters of the lake lie at a height of 9 feet (2·75 m.) or more above mean tide; later in the year as the volume of fresh water draining

*See Map—Suspension Bridge.

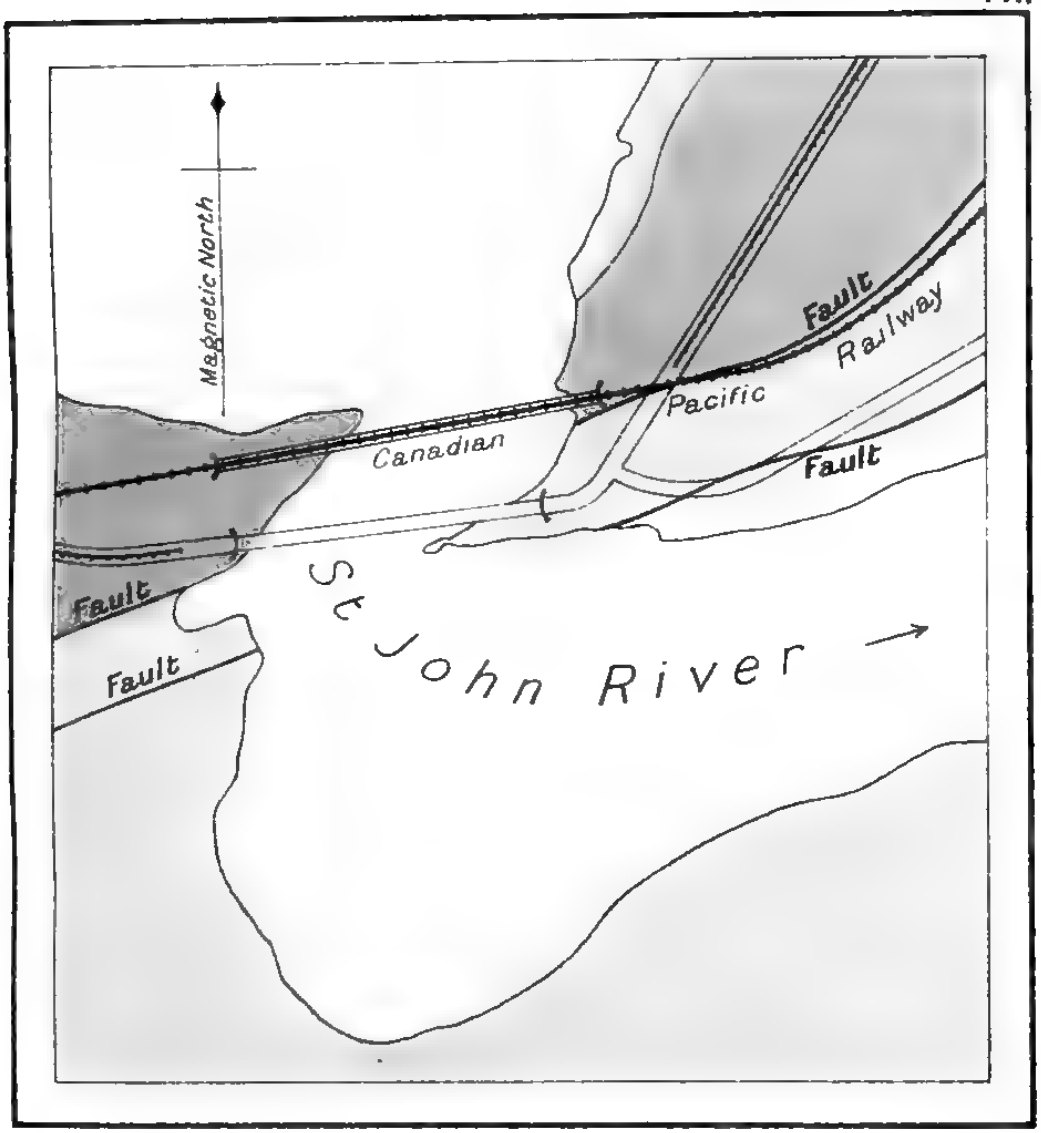


Geological Survey, Canada

Suspension Bridg

Feet
100 0 200 400
Metres
10.0 100

(Scale of map is app



Geological Survey, Canada.

Suspension Bridge, St. John

Feet
100 0 200 400 600 800 1000

Metres
10.0 100 200 300

(Scale of map is approximate)

Legend

- Ordovician
- Cambrian
- Pre-Cambrian
  - Limestone series
  - Quartzite series
- Fault
- Street railway

into the lake decreases, the level of the lake falls to about 3 feet (1 m.) above mean tide. The cause of the higher level of the lake waters relative to mean sea level is due to the constricted nature of the outlet of the lake and to the fact that besides the great volume of sea water entering the lake twice each day there is also an additional large amount of fresh water to be discharged.

The level of high tide in St. John harbour varies between 10 feet and 14 feet (3 m. and 4·2 m.) above mean tide. The waters of the lake rise with the tide only 15 or 18 inches (0·38 or 0·46 m.), therefore at high tide during the latter part of the summer, the water in the St. John channel at Suspension bridge stands 6 to 10 feet (1·8 to 3 m.) above the level of the lake and as a result of the contracted and shallow nature of the channel at the upper falls, the waters there fall inwards. During other portions of the day when the tide level sinks below the lake level, the falls are reversed in direction and the waters fall outwards.

The general configuration of the constricted channel at Suspension bridge is sufficient evidence to indicate that it is not of normal origin. Kennebecasis lake presents many of the general characters of a dammed body of water. The lake and the contiguous lake-like expansions of the St. John river occupy a series of depressions that are portions of valleys belonging to two systems, one of which follows a northwest-southeast course, and the other a northeast-southwest course. The channel of the St. John below Suspension bridge follows a northeast course and therefore belongs to one of the above systems. The lower channel of the river is apparently continued by the depression traversing St. John city and known as the Valley. At Suspension bridge, the depression occupied by the mouth of the river abruptly ends, being cut off by a high ridge from a valley extending some miles to the southwest. It is not improbable that the dividing ridge is composed of unconsolidated material of Glacial and post-Glacial age and that at one time the valleys now heading in this ridge were continuous.

The lake of the lower St. John, whose bottom in places lies nearly 200 feet (60 m.) below sea level, has probably been formed by the empounding of the waters of the drainage system by dams choking the old outlet or outlets. These dams are presumably of Glacial or post-Glacial age. Forced to seek a new outlet, the waters for a time

may have reached the sea by a number of channels, but eventually they appear to have broken over and then through the comparatively low rocky ridge at Suspension bridge and to have found their way to the sea by means of the old valley entered at this place.

The rocks forming the walls of the canyon-like outlet of the St. John river at Suspension bridge are of Pre-Cambrian, Cambrian and Ordovician age. The strata of these three groups are separated from one another by faults that strike in a northeasterly direction. The strata are, in general, steeply inclined and strike in an easterly direction.

The Pre-Cambrian measures outcrop on both sides of the constricted passageway of the St. John and form the northern portion of the walls. They are bounded on the south by Cambrian beds from which they are separated by a fault. The Pre-Cambrian at this place is represented by a band of quartzite flanked on the south by a band of crystalline limestone with beds of black slates and sills or dykes of diabase. The strata are folded, faulted and torn, but in general stand with nearly vertical attitudes.

The Cambrian rocks are largely dark slates and fine sandstone. On the eastern banks of the gorge they form a narrow band separated by a fault from the Pre-Cambrian on the north and by another fault from the Ordovician on the south. These beds have been assigned to the Johannian by Dr. Matthew. The measures bounded by the same faults, occur on the western side of the narrows of the river. They are bounded on the north by Pre-Cambrian rocks while on the south side lie conglomerate, sandstone and shale beds probably of another horizon of the Cambrian, not the Johannian.

The Ordovician measures are largely dark shales. They are exposed in a narrow band along the northern shore of the river below Suspension bridge. The shales are not very fossiliferous, and contain only a few species which are common. *Tetragraptus quadribranchiatus* is the most common fossil, others being species of *Didymograptus*, *Clonograptus* and *Loganograptus*, beside the brachiopods, *Orthis electra major*, and *Strophomena atava*. The Ordovician beds are overturned since they dip southward at high angles thus appearing to underlie the Cambrian strata outcropping on the opposite, southern bank of the tidal river. The Ordovician measures are the highest

preserved members of an overturned syncline which includes the Dictyonema beds of Navy island situated about 1 mile (1·6 km.) to the northeast on the southern side of the channel. The thin-bedded, dark shales on Navy island, are, in places, extremely fossiliferous, *Dictyonema flabelliforme* being particularly abundant. Separated cranidia of trilobites are not uncommon, associated with the Dictyonemas, some of the species found here being *Parabolina heres grandis*, *Parabolinella posthuma*, *Leptoplastus latus*, and *Ctenopyge flagillifer*.

DETAILED DESCRIPTION.

At the end of the street car line on Douglas avenue, at the railway crossing, are exposures of Pre-Cambrian, white, crystalline limestone. The railway runs along the course of the fault separating the Pre-Cambrian from the Cambrian. In the rock cuttings along the north side of the railway, the Pre-Cambrian limestone is exposed, while on the south side of the railway steeply inclined, bent and twisted, dark slates and fine grained sandstones of Cambrian, (Johannian) age outcrop.

The position of the fault bounding the Cambrian on the south is indicated by certain exposures on the Strait Shore road which joins Douglas avenue about 200 feet (60 m.) beyond the railway crossing. On the Strait Shore road about 50 yards (45 m.) east of the junction with Douglas avenue, are outcrops of twisted and torn, Cambrian slates and sandstones. These measures are exposed on the north side of the road, while in the gutter on the same side of the road are exposures of dark shales supposedly of Ordovician age since they are lithologically very similar to the graptolite-bearing beds of this age outcropping a few yards to the south in the cliffs along the shore of the river. The fault plane separating the Cambrian and Ordovician, is visible in the cliff face at a point just opposite the anchor pier of the Suspension bridge.

From a view point on the western shore between the two bridges, the fault separating the Pre-Cambrian and Cambrian is plainly indicated in the steep rock cliffs about 20 feet (6 m.) south of the railway bridge. The position of the nearly vertical fault is made apparent by the contrast between the white, Pre-Cambrian limestone on the north

and the dark Cambrian slates on the south. The crystalline limestone beds as indicated by the associated dark rocks, are much torn. The limestones are succeeded on the north by quartzites and the boundary between these two formations is in part at least, a fault plane whose general course is indicated by the ledges of white quartzite outcropping beyond the railway bridge and a short distance

Fault between Tetragraptus shale and Acadian, near Suspension bridge, St, John, N.B.

back from and approximately parallel to the cliffs forming the shore of the river.

The fault plane separating the Cambrian and Ordovician is visible from the hillside south of the highway on the western side of the river. The two sets of strata do not sharply contrast in colour. The dense black, Ordovician shales form the cliff back to two ruined docks, while the greyer Cambrian measures form the rocky projection extending westward parallel with and to the south of the highway bridge.

The small, bay-like indentation on the west side of the river immediately below the highway bridge, marks the line of the fault between the Pre-Cambrian and Cambrian

on the west bank. The fault on the eastern shore between the Cambrian and Ordovician presumably continues on the west side of the river and apparently passes close to the small pavilion standing near the shore. The fault at this place brings lithologically dissimilar Cambrian beds into contact with one another.

SUSPENSION BRIDGE TO SEASIDE PARK (FERN LEDGES).

The street car route from Suspension bridge to Seaside park for a short distance follows a westerly course overlooking the St. John river which is bordered on both sides by Pre-Cambrian rocks consisting of crystalline limestone, quartzite, etc., and large intrusive bodies of granite and diorite. The street car route is situated on the northern slope of a ridge which possibly is composed altogether of unconsolidated materials since on the lower slopes, towards the river, heavy cuttings reveal a very considerable thickness of stratified clays and sands.

Shortly after leaving Suspension bridge, the street car route turns sharply to the southeast and passes along the western edge of the summit of the above mentioned hill. To the southwest extends a long broad valley joining the valley of the St. John to the southwest. This valley is continued on the eastern side of the ridge by the lower reaches of the St. John river and by the valley running northeasterly through St. John city.

At the junction with the street car line leading eastward to Carleton, are outcrops of dark, basic volcanic rocks. Similar rocks outcrop at intervals along and at the end of the street car route at Seaside park. These basic rocks form a thick zone apparently interbanded or interbedded with the lower portion of the Little River group. Similar rocks in a similar stratigraphical position outcrop in St. John city and farther east on the shore of Courtenay bay. The igneous rocks vary considerably in appearance from moderately coarse diabase to fine-grained, porphyritic and amygdaloidal varieties. In places they appear to have slightly metamorphosed the overlying sediments. The basic igneous rocks possibly are eruptives, though it is more probable that they form an intrusive, sill-like body.

At Seaside park, at the end of the street car line, the basic igneous rocks are exposed at intervals along the path leading across the railway to the shore and to the Fern Ledges. Where the path crosses the railway are exposures of quartzose sandstone belonging to the Dadoxylon division of the Little River group. The measures dip seaward (to the south) at an angle of 30°. Similar measures are exposed a short distance farther, but from this point to the beach, to the locality of the Fern Ledges, the strata are concealed.

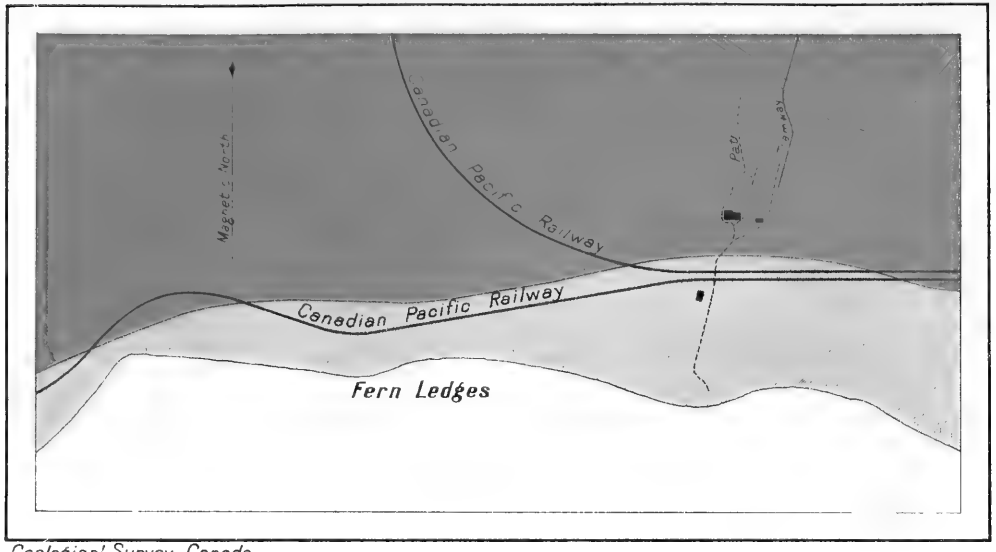
FERN LEDGES.*

(Mary C. Stopes)

Editorial Note.—Recently Dr. Mary C. Stopes has prepared for the Geological Survey of Canada, a memoir on the flora of the Fern Ledges. This memoir is not yet published but permission has been obtained to make use of the information contained in the manuscript in the preparation of the following account of the geology and flora of the Fern Ledges. Dr. Stopes was able to assemble nearly all the original specimens of the Fern Ledges flora and studied them as well as a great mass of new material obtained from Duck Cove, a short distance west of the type locality. The following account is essentially an abstract of the unpublished memoir by Dr. Stopes. Certain portions of the manuscript have been extracted word for word; such portions are indicated by quotation marks.

"The fossil plants of the St. John Fern Ledges in the Little River group occupy a unique position in the annals of palæontology owing to the extensive..... discussions they have aroused ever since (so long ago as 1861) Sir W. Dawson began to describe them as representatives of a Devonian flora. Sir W. Dawson from time to time named and illustrated the majority of the species described from the beds. At this early date comparatively few figures of European and other American Palæozoic fossil plants were available for his use and so it is not surprising that Sir William made new species from most of the specimens. As a consequence, judging to-day by the list of species described from the locality, one receives the impression that the "Little River" flora is an isolated and peculiar one. In quite recent years, Dr. Matthew.....has been publishing

* See Map—Fern Ledges.



Geological Survey, Canada

Fern Ledges

Feet
600 0 500 1000 1500

Metres
100 0 100 200 300 400 500

(Scale of map is approximate)

Legend

Little River group

Basic eruptives

revisions and additions to this interesting flora and latterly he has maintained that the plants are of Silurian age."

Sir W. Dawson in his various descriptions of the flora pointed out the Carboniferous aspect of many of the species. "As early as 1866 Geinitz pointed out that the insects described by Scudder as Devonian were on the same slab as a fragment of *Pecopteris plumosa*" and that this suggested that the strata were of Carboniferous and not Devonian age. The controversy as to the age of the flora did not take a serious aspect until thirty years later when attention was forcibly directed to the matter in connexion with a discussion of the age of the Riversdale-Union formations of Nova Scotia which on floral, lithological and stratigraphical grounds were correlated with the Little River and associated strata.

Dr. J. F. Whiteaves in 1899, in a vice-presidental address to the American Association for the Advancement of Science presented extracts from manuscript reports prepared by Dr. Kidston and Dr. David White, in which both of these palæobotanists maintained that the Fern Ledges were of Carboniferous age. Dr. White in another publication very definitely correlated the Fern Ledges with the Pottsville.

In 1906, Dr. G. F. Matthew commenced a revision of the flora of the Fern Ledges and took up the position that the flora was Devonian, but later, in 1910, asserted that it was Silurian.

The classic locality for the Fern Ledges fossil plants is on the shore between high and low water, at Seaside park, a mile west of Carleton a suburb of St. John. "The same strata are repeated along the shore of Duck Cove, where the most prolific beds now lie, for the original sections at the Fern Ledges are both nearly worked out and have been covered to a considerable extent by the drifting sand and gravel of the shore. The same series also outcrops to the east of St. John harbour where some plants are to be found if they are carefully sought for, but the extent of alteration in the shales is much greater here, and the fossils are seldom sufficiently well preserved to repay collection, except merely for identification in the field." The same beds occur to the west of the Fern Ledges locality, and outcrop on the shore at Lepreau harbour where "fossil plants are to be found, but these specimens also have but little value beyond indicating the identity of the beds in which they occur. One may take it that practically all the plants

of importance to the palæobotanist originated from the Fern Ledge section of Carleton, or from one of the numerous beds a little further around the coast toward and just beyond Duck Cove."

"The Fern Ledges series consists of alternations of sandstones and shales. In the compact, heavy grey sandstones but few fossils, and those principally fragments of woody stumps, are to be found. In the numerous beds of fine grey or blackish shale, which is laminated and

The "Fern Ledges," St. John, N.B.

in many places, is considerably altered, a rich flora of debris occurs. The more or less altered shale occurs in beds ranging from a couple of inches to a couple of feet in thickness." At Duck Cove, at the present time the best collecting locality, the plant-containing bands are more numerous than in the original section at the Fern Ledges as reported by Hartt and Matthew. The beds dip at an angle of about 30° to 50°. There are several minor faults which tend to cause repetitions of the series but even allowing for this there cannot be less than 20 bands of plant-containing shales, of various thickness, most of them containing a great variety of plants.

Previous accounts seemed to indicate that the various shale bands might represent zones in a geological sense. This, however, does not appear to be the case though it is not impossible that extensive and careful work over the

whole outcrop may reveal definite assemblages in a definite sequence.

"The general appearance of the fine shale bands alternating with the sandstones, is that of a deltaic deposit, probably at the mouth of a great river or at its entry into a lake or it might be, the bend of a lagoon (the remarkable lack of marine fossils in the neighbourhood renders some such view very probable). The deposits appear to have collected rapidly (geologically speaking). The difference in the species of the plants brought down from time to time in the current of the river can be readily accounted for by slight changes in the course of the water, or by flood effects in different parts of its course. The Fern Ledges flora is the remains of the inland flora of the period, and one which had travelled down stream as debris for some distance before being entombed. It is, therefore, natural that sometimes one, and sometimes another species should preponderate in the various beds now appearing in consecutive order; but the sequence of these plant remains depended on local, fortuitous accidents, and do not appear to be an indication of appreciable differences of geological time."

The plants in this series of beds are found in two forms. (1) Scattered, isolated and infrequent trunks or branches, some of Calamites, but mostly of branches of gymnospermic wood of an ancient type generally known as Dadoxylon. These occur principally in the sandstones alternating with the shale bands. (2) The impressions of ferns, Cordaites, Calamites, and other plants, forming the debris of a rich, mixed flora, preserved in the series of shale bands. It is unfortunate that these impressions are all much altered. They often occur on slickensided surfaces, and locally the shales have quite a slaty cleavage. The plant impressions have been completely graphitized and most of them consist merely of a bright film or streak on the rock.

"Though over 80 "species" have been from time to time described from the Fern Ledges flora, among all these only about 40 are of value and have been determined on a sufficiently sound basis to make them of any real use in the comparison of this flora with others." In the following list are given only such species as are thought to have been determined from material that by competent palæobotanists would be universally considered to be

sufficiently good to enable the species to be reliably determined.

Calamites suckowi Brongnt.
Annularia sphenophylloides Zenker.
Annularia stellata Schlotheim sp.
Annularia latifoila Dawson sp.
Stigmaria ficoides
Adiantides obtusa Dawson sp.
Rhacopetris busseawa Steer
Sphenopteris marginata Dawson
Oligocarpia splendens Dawson sp.
Sphenopteris valida Dawson sp.
Pecopteris plumosa Artis.
Diplothmema subjurcatus Dawson sp.
Alethopteris lonchitica Schlotheim sp.
Megalopteris dawsoni Hartt sp.
Neuropteris heterophylla Brongnt.
Neuropteris gigantea Sternberg
Sporangites acuminata Dawson
Pteriopermostrabus bifurcatus Stopes
Dicranophyllum glabrum Dawson sp.
Whittleseya dawsoniana D. White
Whittleseya concinna Matthew
Cordaites rubbii Dawson
Cordaites principalis German sp.
Dadoxylon ouangondianum Dawson
Cordaianthus devonicus Dawson sp.
Cardiocarpon obliquum Dawson
Cardiocarpon baileyi Dawson
Cardiocarpon cornutum Dawson
Cardiocarpon crampii Hartt.

Every species of importance is a typical Carboniferous one. By David White the plant-bearing Fern Ledges have been correlated with the Pottsville; by Kidston they have been correlated with the European Lower Coal Measures. By White the upper part of the Pottsville is considered to be very nearly contemporaneous with the Lower Coal Measures of Europe. But it would appear that the Fern Ledges represent a somewhat higher zone than that assigned by White.

If a comparison be made between the Fern Ledges and Westphalian floras it is at once evident how remarkably

Westphalian is the character of the Fern Ledges flora. "The genus Megalopteris alone, is entirely unrepresented in the Westphalian of Europe, but it is a peculiar form which is confined (though recently Arker identified a small fragment from the British Coal Measures as belonging to this genus) to North America, where it has been recognized in beds of undoubtedly Pottsville age. Otherwise the leading species have not merely allies in the Westphalian flora of Europe, but are identical in the majority of cases. We may take it as indisputable that the Fern Ledges flora is of Westphalian age and that probably it corresponds in point of time most nearly to the lowest zone of the middle Westphalian. The specific identity between so many of the plants from Europe and Canada is a point of great interest in relation to the geographical distribution of the forms."

BIBLIOGRAPHY.

The general geology of the area in the vicinity of St. John city, and the faunas of the Cambrian and the flora of the Little River group have been exhaustively dealt with by Dr. G. F. Matthew in a long series of articles appearing in the Proceedings and Transactions of the Royal Society of Canada from volume I (1882-83) onwards. A few of the other more important contributions to the general subject are as follows:—

Bailey, L. W. Geol. Surv. Can., Report of Progress 1877-78.

Dawson, W. J. Acadian Geology.

Ells, R. W. Geol. Surv. Can., Geology and Mineral Resources of New Brunswick, 1907.

Walcott, C. D. Proceedings Washington Academy of Sciences, Vol. I, p. 301, 1900.

ANNOTATED GUIDE.

ST. JOHN TO GRAND FALLS.

(G. A. YOUNG.)

Miles and Kilometres

0 m.
0 km. **St. John**—From St. John city, the Canadian Pacific railway runs northward for about 15 miles (24 km.) along the western side of the lower St. John, traversing in this distance a region underlain almost entirely by Pre-Cambrian strata. Leaving the St. John valley, the railroad strikes northwestward across a broken hilly country occupied by Silurian and older strata and large batholithic areas of granite.

At a distance of about 20 miles (32 km.) from the St. John valley, the railway crosses the southern border of the Carboniferous area which, terminating not many miles to the west, extends in a northeasterly direction for more than 150 miles (240 km.). Crossing the comparatively narrow southwestern extension of the Carboniferous area, the railway enters a second area of Silurian and older rocks penetrated by large bodies of granite. This broad belt of strata extends in a northeasterly direction across the province. The railway crosses it in a northerly direction and near its northwestern boundary descends into the valley of the St. John river at Woodstock which is situated on the west bank of the river.

135·1 m.
217·4 km. **Woodstock**—Alt. 136 ft. (41·4 m.). At Woodstock and for many miles to the north, the St. John river is a broad, swift-flowing stream in places occupying nearly the whole width of the valley bottom, in other places bordered on one side by a flat in some cases nearly one mile (1·6 km.) wide. Everywhere the valley walls rise steeply and the general level of the country on both sides has an average altitude of between 500 and 600 feet, (150 and 180 m.). On the western side of the river, the country is plateau-like, while on the eastern side, many

isolated hills and ridges attain altitudes of above 1,000 feet (300 m.).

At Woodstock the country on both sides of the river is underlain by strata that have been classed with the Ordovician. The measures are everywhere tilted at high angles and in many places are closely folded or contorted. The strata in places are penetrated by large and small bodies of granite. Besides slates, sandstones and occasional beds of limestone, "felsites," diabase, and other fine-grained igneous rocks occur. In many places the strata are much metamorphosed and are schistose or gneissic. These or similar rocks form a wide zone extending for many miles to the northeast to the Bay of Chaleur. At one or two localities fossils possibly of Ordovician age have been found in the rocks of this assemblage. In a very few other places, Silurian and lower Devonian fossils have been found.

These "Ordovician" strata are bounded on the northwest by measures classed with the Silurian. At Woodstock, the boundary between the "Ordovician" and Silurian lies about $1\frac{1}{2}$ miles (2·4 km.) to the west. This boundary, pursuing a northeasterly course, crosses the river about 10 miles (16 km.) above Woodstock.

Two miles (3·2 km.) above Woodstock, the railway crosses the St. John river to the east bank. Above this point, the Ordovician strata west of the river are confined to a very narrow strip. Along the boundary with the Silurian occur detached areas of coarse red conglomerate with some finer materials. These measures in places dip with angles as high as 60°; they have been considered to be of Lower Carboniferous age.

About 10 miles (16 km.) from Woodstock, the railway crosses the northeasterly extending boundary of the "Ordovician" and enters the Silurian which extends from this point northwards for 150 miles (240 km.), almost to the shores of the St. Lawrence. Over the many hundreds of square miles of territory that have

Miles and Kilometres.

been mapped as underlain by Silurian strata, fossils have been recovered from only a very limited number of localities. While perhaps in the majority of the cases the fossils are of Silurian age, in other cases they are definitely known to be of Devonian age. Possibly it would be more correct to consider the underlying strata of this very extensive "Silurian" area as being an assemblage of measures ranging in age from lower Devonian to Silurian or even older. The bulk of the strata are grey, calcareous slates and slate-like, impure limestones. In places heavy beds of purer limestone occur and these in some cases are fossiliferous. Beside the above mentioned rocks, grey, green and red slates, grey sandstones and conglomerates also occur and locally bodies of fine-grained, perhaps effusive, igneous rocks are present. The strata are everywhere closely folded.

147·4 m. 237·2 km. **Hartland Station**—Alt. 151 ft. (46 m.).

183·6 m. 295·5 km. **Perth Station**—Alt. 243 ft. (74 m.). At Perth, the railway crosses to Andover on the west side of the St. John. The strata underlying the country on both sides of the St. John river from Hartland to Perth, all belong to the "Silurian" and are largely grey, slaty rocks varying in composition from a slate to an argillaceous limestone.

184·8 m. 297·4 km. **Andover Station**—Alt. 257 ft. (78·3 m.). Several miles above Andover, the Tobique river joins the St. John from the northeast.

189·2 m. 304·5 km. **Aroostook Junction**—Alt. 271 ft. (82·6 m.) Just beyond Aroostook Junction, the railway crosses Aroostook river a large tributary from the west.

200·1 m. 322 km. **Ortonville Station**—Alt. 352 ft. (107·3 m.). About opposite Ortonville station, Salmon river flowing from the northeast joins the St. John. The valley of Salmon river is as deep and as pronounced as that of the St. John and has the appearance of being the northeastward continuation of the St. John valley.

Miles and Kilometres.

Five miles (8 km.) above Ortonville station, the railway leaves the river side and commences to ascend the side of the stream valley.

207·7 m. 344 km. **Grand Falls Station**—Alt. 507 ft. (154·5 m.).

GRAND FALLS, ST. JOHN RIVER.*

(G. A. Young.)

INTRODUCTION.

The St. John river both above and below Grand Falls, flows in a broad pronounced valley which in the neighborhood of Grand Falls gradually bends from a general southeasterly course above to a more nearly due south course below. Above Grand Falls, the St. John valley is probably in many places 5 to 10 miles (8 to 16 km.) wide and for a distance of about 35 miles (56 km.), the river current is comparatively feeble and the banks of the river low. Below Grand Falls, the river valley is narrower, the current swift and the stream in many places is bordered by steep banks 50 to 175 feet (15 to 50 m.) high. Both above and below Grand Falls, the St. John is bordered by river terraces but these are much more markedly developed below Grand Falls than above.

At Grand Falls the St. John river abruptly diverges from its general southerly course and swings easterly through a semi-circular course having a radius of about 2,000 feet (600 m.). In this abrupt bend of the river, the waters pour over a vertical fall of about 60 feet (18·3 m.) and, in a deep canyon beyond, descend in a series of cascades and rapids a further vertical distance of about 55 feet (17·7 m.); the total drop in this part of the river being 115 feet (30 m.). The abrupt bend in the river, the falls, the deep canyon, etc., all very obviously indicate that this portion of the river channel is of comparatively recent age, and the position of the old channel, now at least partially filled with bedded sands and gravels, is shewn in the banks of

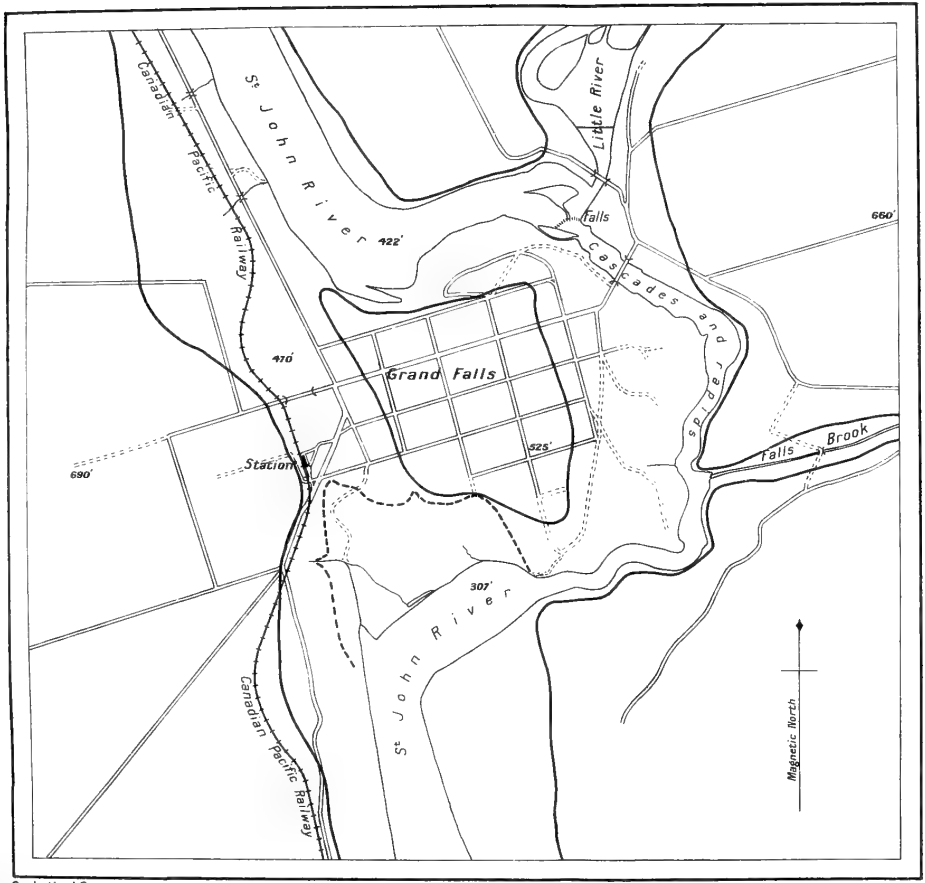
*See Map, Grand Falls.

the river valley where the newer waterway rejoins the older.

Two geologists, Hind and Chalmers have offered explanations of the main causes whereby the St. John at Grand Falls was deflected from its original course and forced to carve out a new channel. Hind [**2**, pp. 31, 132 and 207-8] writing in 1865, believed that following the Glacial period, the whole region was submerged beneath the sea and that during this interval of submergence the St. John valley was partially filled with unconsolidated material. Subsequently as the land rose, the river cut into and removed this filling material but during this process of re-excavation, the river at Grand Falls, as it cut its way through the overburden, departed from the course of the original channel and as a result eventually carved out a new channel in solid rock.

Chalmers [**1**] in various articles, advanced the view that during the Glacial period the St. John valley was largely filled in with both stratified and unstratified material of glacial origin. After the final retreat of the glacial ice, the unconsolidated material, in places as at Grand Falls, formed dams that diverted the river from its old channel and caused it to excavate a new channel through solid rock.

The general hypothesis favoured by the writer is that during the Glacial period while the region was mantled with ice, the St. John valley was also filled with ice and comparatively little unconsolidated material was there deposited. Later, perhaps during an inter-glacial period if such occurred, but more probably during and after the final retreat of the ice, the river for a variety of causes, was overburdened with detrital material and as a consequence largely filled in the pre-existing valley. At a still later date, the river, no longer overloaded, re-excavated its ancient channel except where for perhaps minor causes, it was diverted and carved out new channels. In the case of the new channel at Grand Falls, it is thought that one factor that caused the river to form a new channel, was the existence of a deeply cut channel in the case of a minor tributary, Falls brook, coming in from the east.



Legend

Edge of rise from 507-foot terrace

Crest of cliffs of unconsolidated materia

307' Figures, showing heights in feet above sea-level

Geological Survey, Canada.

Grand Falls

Feet

500 0 1000 2000

Metres

100 0 200 400 600

(Scale of map is approximate)

DETAILED DESCRIPTION.

The railway at Grand Falls station and for some distance northwards, runs on the floor of a river terrace having an altitude of 507 feet (154·5 m.). A short distance north of the station, there is on the west side of the railway tracks, a small cutting in cross-bedded sands and gravels illustrating the nature of the material in which the terraces have been carved.

About 200 yards (180 m.) north of the railway station, a road crosses the railway tracks and runs for some distance to the southwest up the slopes of the ridge bounding the St. John valley on the west. In the opposite direction, to the northeast, the road forms the principal street of the town of Grand Falls and leads to the bridge crossing the St. John river below the falls. At this road crossing, the eroded scarp of the 507-foot terrace floor on which the railway runs, is plainly visible a short distance to the west rising to a second terrace floor having an elevation of about 530 feet (161·5 m.). Beyond this another scarp is visible rising to a terrace floor having an elevation of about 560 feet (170·7 m.). Still farther up the slope of the hill which rises to an altitude of about 690 feet (210 m.), other, more faintly marked, bench-like steps occur. Besides the main terrace scarps, other much more faintly marked intermediate ones occur. These terraces were presumably formed when, after the main valley had been filled in to a height of about 600 feet (180 m.) by stratified sands and gravels, the St. John river commenced to re-excavate its valley, and they mark successively lower stages of the probably rapidly falling river level.

The 507-foot terrace floor and the scarp rising from it form the most strongly developed terrace in the neighborhood. This terrace is present on both sides of the St. John valley and extends up the valleys of the several tributaries. It also occurs in the centre of the valley surrounding the rising ground on which the town of Grand Falls is built. At the time when the river flowed over the 507-foot terrace floor it occupied two channels separated by an island now the site of the town of Grand Falls; the eastern channel eventually developed into the present channel of the river, while the western channel which

followed the course of the pre-Glacial river bed was abandoned shortly after the waters fell below the 507-foot level.

The original, pre-Glacial channel passes just east of the railway and its course is now marked by a depression crossed by a bridge at the western continuation of the main street of Grand Falls. At the bridge crossing, the elevation of the bottom of the depression is about 495 feet (150·8 m.). To the south, the bottom of the depression is nearly level, perhaps even falls a little in that direction, but farther south the bottom of the depression distinctly rises. In the opposite direction, to the north, a small stream enters the depression and flows northward with a constantly increasing gradient. This depression was perhaps outlined by the former western channel of the St. John river just before the final abandonment of this western passage. The bottom of the depression, however, rises to the south that is, downstream. This slight rise in the bed in the direction of the flow of the water may possibly only represent slight inequalities in the former river bed. The shape of the depression, on the other hand, has been obviously modified by streams tributary to the main river and perhaps it is to the action of such streams that the depression is largely or even wholly due.

Across the depression, to the east on the main street of Grand Falls, a slight rise leads to a terrace floor of the same elevation (507 feet or 154·5 m.) as that on which the railway runs. Farther on, the street rises to a higher terrace floor; beyond this the road descends to the 507-foot terrace floor whose scarp is plainly visible to the south of the road. Still farther to the east, approaching the canyon of the St. John, the road crosses other, lower terraces.

From the bridge over the St. John a splendid view is obtained of the falls at the head of the rock-walled gorge. The water enters the gorge by a vertical drop of about 60 feet (18·3 m.) and below this descends between vertical walls in a continuous series of cascades and rapids that continue down stream for a distance of 1,000 yards (900 m.), beyond which quiet water is reached. Looking westward up the river, a stream of considerable magnitude—Little river—may be seen joining the St. John just above the brink of the Falls. From the eastern end of the bridge a view may be obtained of the sharp bend of the St. John river where it leaves the course of the original channel.

Little river, the tributary entering the main river just above the falls, flows over a rock floor just before it joins the St. John and therefore, it is presumed, has also abandoned its pre-Glacial channel. This large affluent may have given rise to one of the causes whereby the St. John was led to abandon the western channel, since it is conceivable that by joining the St. John at this place, the erosive power of the eastern branch was increased over that of the western branch.

The first branch road running south, west of the bridge, joins a pathway leading to the edge of the gorge of the St. John opposite the mouth of Falls brook. This road and path pass over a terrace floor having an elevation of about 495 feet (150·9 m.). This terrace level is in places at least, rock-floored. Where the pathway approaches the edge of the gorge, it descends to a lower terrace floor having an elevation of about 450 feet (140 m.).

At the edge of the gorge, the rock walls rise almost vertical for 160 feet (49 m.). Upstream the nearly perpendicular walls are higher. Looking up the St. John from this view point, the river may be seen descending over a continuous series of cascades and rapids which abruptly cease at this place and give way to comparatively quiet waters which continue down the curving gorge to where it joins the broad stream channel of the original course of the St. John. Where this marked change in the character of the river bottom commences, there is also a change in the character of the slopes bounding the gorge. Above, the walls are nearly vertical but below, they are much less steep and in a general way are patterned like the bounding slopes of Falls brook which enters directly opposite the view point.

Falls brook at its mouth empties over a rock lip about 30 feet (9 m.) high, into the comparatively quiet waters of the St. John. Inland the bed of the brook rises about 250 feet (75 m.) in the first mile. Towards the mouth of the brook, the gradient of the stream is much less than the above average rate and when plotted in profile suggests that if Falls brook flowed with its normal gradient down the lower portion of the gorge now occupied by the St. John, it would enter the main valley of the St. John at grade. This suggestive line of evidence, together with others such as the hanging relation of Falls brook, the existence of quiet water in the lower part of the gorge of the St. John as far

up as the mouth of Falls Brook and the presence of a long series of rapids and cascades above it, and the change in the character of the valley walls at the mouth of Falls brook, indicates that the lower part of the gorge of the St. John was once part of the valley of Falls brook and that this portion of the valley is of pre-Glacial age. The existence of this valley appears to have been one of the factors that caused the St. John to carve out its new valley. In doing this the St. John lowered the original gradient of the lower part of Falls brook so that the valley of this brook is now a hanging valley. Where the St. John entered the valley of Falls brook, a fall was established which has since receded to its present position, 2,800 feet (850 m.) upstream. Eventually these falls may retreat as far as the pre-Glacial site of the river above the falls. If this should occur, the St. John would speedily re-excavate the upper portion of its course.

The exit of the gorge of the St. John may be seen from the top of the steep banks overlooking the river about 200 yards (180 m.) east of the railway station. This view point is situated close to the western slope of the old valley of the St. John for a succession of rock ledges outcrop along the western shore and bounding slopes that stretch in a straight line to the south. To the east, distant about 600 yards (550 m.), the rock-walled mouth of the gorge of the St. John is visible where it enters at right angles into the older course of the St. John still occupied by the river. Between the rock cliffs at the mouth of the gorge on the east and the steep slopes on the western side, there runs a curving escarpment convex towards the north whose crest lies about 200 feet (60 m.) above the waters of the St. John. This escarpment has been formed in the unconsolidated material filling the abandoned portion of the river channel. The upper part of this escarpment is cliff-like and is there seen to be composed of bedded sands and gravels. The lower, greater part of the escarpment is mantled by talus and the nature of the material occupying the lower part of the old valley cannot be directly determined. It is assumed that it is of the same character as that filling the upper portion. That the thickness of this material is no greater than the height from the level of the St. John waters to the top of the escarpment, is indicated by the outcrops of rock occurring at the foot of the talus slope along the side of the river. These rock outcrops are

evidently a portion of the rock floor of the abandoned pre-Glacial channel.

BIBLIOGRAPHY.

1. Chalmers, R. Geol. Surv. Can., Report of Progress for 1882-83-84, part GG., pp. 12-13, 35-37, 1885.
" " Geol. Surv. Can., Annual Report, Vol. I, Part G.G., pp. 38-39, 1886.
" " Geol. Surv. Can., Summary Report for 1894, p. 82, 1895.
" " Geol. Surv. Can., Summary Report for 1899, p. 149, 1900.
" " Geol. Surv. Can., Summary Report for 1900, pp. 152-53, 1901.

2. Hind, H. Y. Preliminary Report on the Geology of New Brunswick pp. 31, 132, 207-8, Fredericton, 1865.

ANNOTATED GUIDE.

GRAND FALLS TO RIVIÈRE DU LOUP.

(G. A. YOUNG.)

Miles and Kilometres.

0 m. 0 km. **Grand Falls**—Alt. 507 ft. (154·5 m.). About 1 mile (1·6 km.) above Grand Falls the Canadian Pacific railway crosses the river to the eastern side along which it runs to Edmundston. The country bordering the St. John is hilly though few of the hills are of any considerable elevation. Approaching Edmundston the country begins to be rugged. Very few rock exposures occur along the river and these in most cases are dark slates. At one locality a few fossils have been found of about Niagara age, but the strata in general have been considered to be late Silurian or early Devonian.

38·7 m. 62·3 km. **Edmundston**—Alt. 468 ft. (142·6 m.). From Edmundston, the Temiscouata railway runs northwestward up the valley of Madawaska

Miles and Kilometres.

river, one of the larger tributaries of the St. John. The valley of the Madawaska is flat-bottomed and rock exposures are rare. Such outcrops as occur are of dark slate of Silurian age.

59·3 m. 95·4 km. **Ste. Rose Station**—Alt. 504 ft. (153·6 m.). About 1½ miles (2·4 km.) beyond Ste. Rose station, the railway approaches the foot of Temiscouata lake, out of which the Madawaska river flows. The railway for a number of miles closely follows the southwestern shore of the lake. Temiscouata lake is about 24 miles (38·6 km.) long and varies between 1 and 2 miles (1·6 and 3·2 km.) in width.

The strata along the shores of the southern part of the lake consist of tightly folded and contorted dark grey slates and argillaceous limestones with occasional beds of sandstone. These measures are of Silurian age and are exposed in a number of cuttings along the railroad.

68·1 m. 109·6 km. **Notre Dame du Lac Station**—Alt. 517 ft. (157.6 m.). The folded crumpled dark slates occur in a number of cuttings along the railway for about 3 miles (4·8 km.) beyond Notre Dame du Lac station. Beyond this for a distance of several miles occurs a thick series of strata in places containing fossils of Niagara or perhaps Clinton age. The series in part consists of slates and sandstones, in part of fine-grained tuffs and volcanic conglomerates. The volcanic strata consist of slightly waterworn fragments of andesite, devitrified glass, etc. The same strata are repeated on the northeastern shore of the lake.

76·3 m. 122·8 km. **Cabano Station**—Alt. 500 ft. (152·4 m.). On the northeast shore, opposite Cabano, Mount Wissick rises 550 feet (167·6 m.) above the lake, to an altitude of 1,035 feet (315 m.). Mt. Wissick is formed of Silurian strata dipping to the southeast at angles of 15° to 70°, and these measures there yield a section of above 1,950 feet (595 m.) of strata which in places are richly fossiliferous and have been described as

Miles and Kilometres.

being of uppermost Silurian or lowermost Devonian age. These measures along the northern base of Mount Wissick repose on strata of the Quebec group over which it seems likely they have been thrust.

A short distance beyond Cabano, the railway swings away from the lake and following a westerly direction crosses the boundary of the Silurian area about 2 miles (3·2 km.) west of Cabano. From this point the railway crosses the zone of the Quebec group strata that borders the lower St. Lawrence, and which at this point has a width of about 30 miles (48 km.). These measures are usually vertical or steeply inclined to the south suggesting that the strata for the greater part occur in a series of overturned anticlines. The beds occur in alternating bands of grey sandstones and grit, and grey, green and red slates. These measures have been classed with the Sillery and considered to be of Cambrian age. Possibly, however, other strata are present. The strata are exposed in numerous cuttings along the railway.

Westward from Cabano, the railway ascends through a country occupied by long low ridges and hills and 19·3 miles (31 km.) from Cabano station crosses a summit level having an altitude of 1,324 feet (403·5 m.). Beyond this, the railway gradually descends through a less broken country to the lower levels bordering the St. Lawrence.

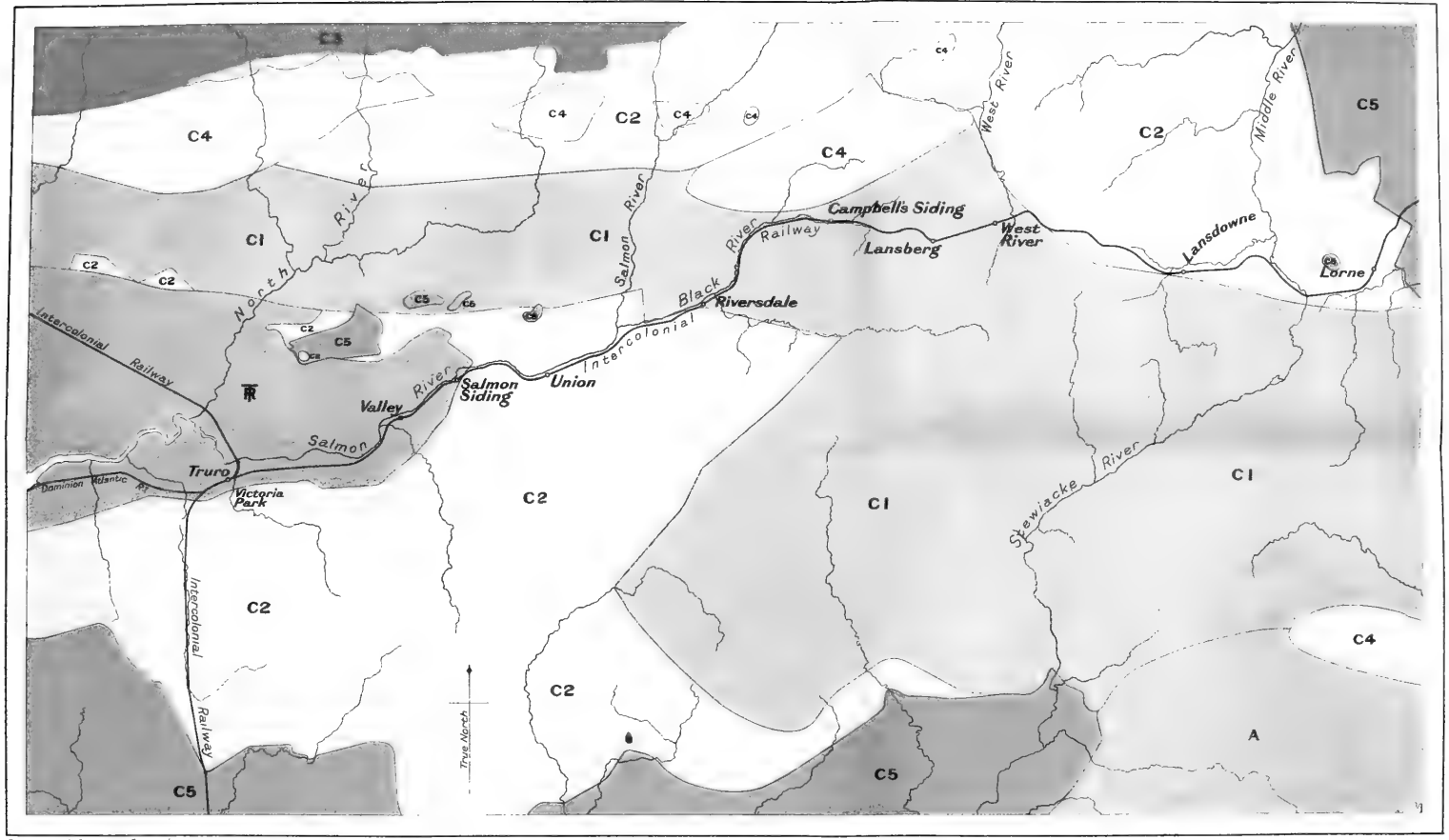
119·6 m. 192·5 km. **Rivière du Loup**—Alt. 316 ft. (96·3 km.). Rivière du Loup is the junction point of the Temiscouata railway and the Intercolonial railway.

234·1 m. 376·7 k.m. **Lévis**—For description of route from Rivière du Loup to Lévis via the Intercolonial Railway, see pages 52-56.

396·9 m. 638·7 k.m. **Montreal**—For description of route from Lévis to Montreal via the Intercolonial Railway, see pages 24 and 25.

513·1 m. 825·7 k.m. **Ottawa**—

Pocket contains
4 items



Geological Survey, Canada

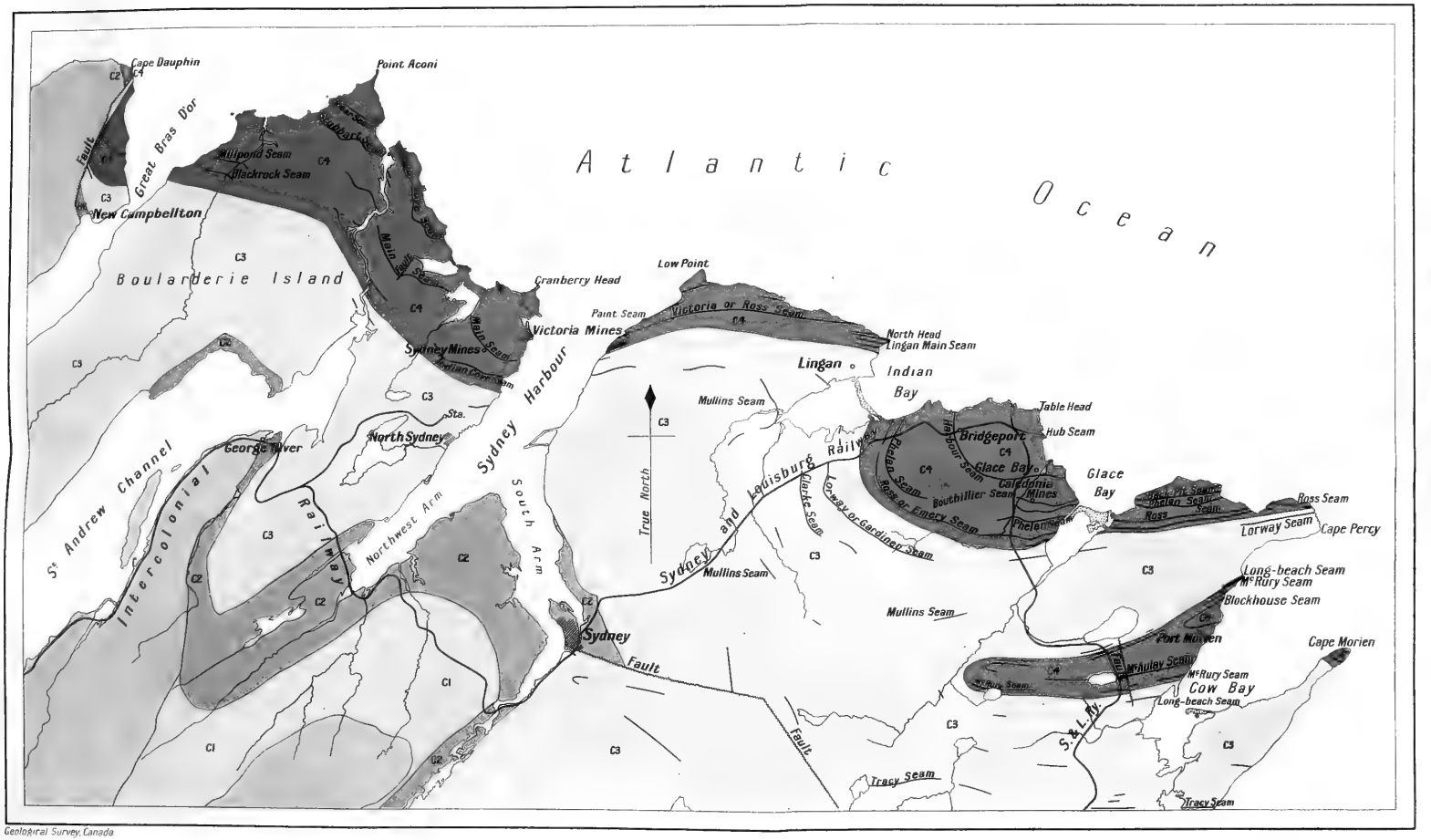
Union – Riversdale

Miles
Kilometres

Carboniferous

Legend

- Triassic
- C5 Windsor series
- C4 Conglomerate
- C1 Igneous rocks, intrusive and extrusive(?); schists and sediments
- C2 Union
- C1 Riversdale
- A Pre-Cambrian(?) Gold-bearing series and Devonian(?) granite

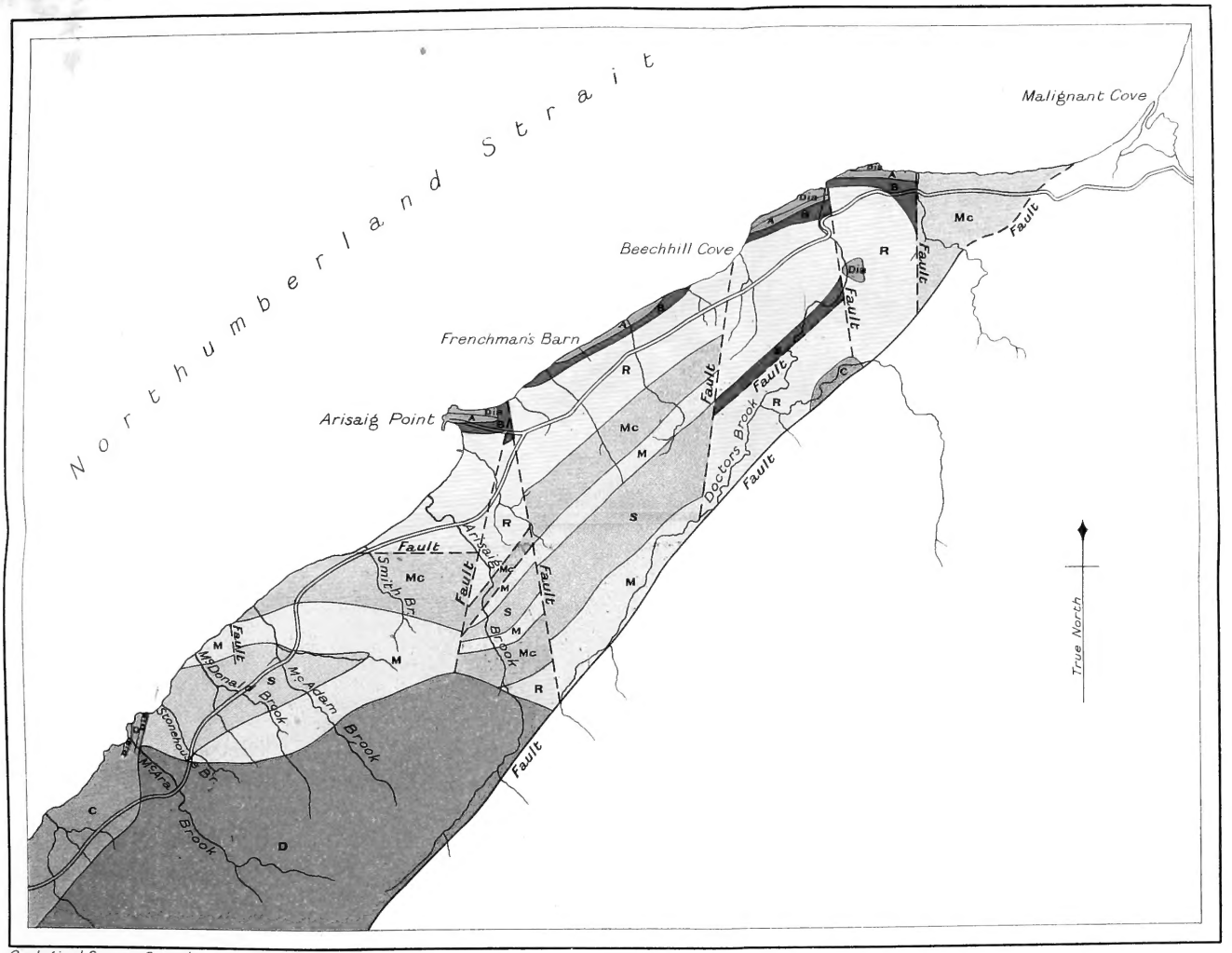


Geological Survey, Canada

Sydney Coal Field

Miles

Kilometres



Geological Survey, Canada.

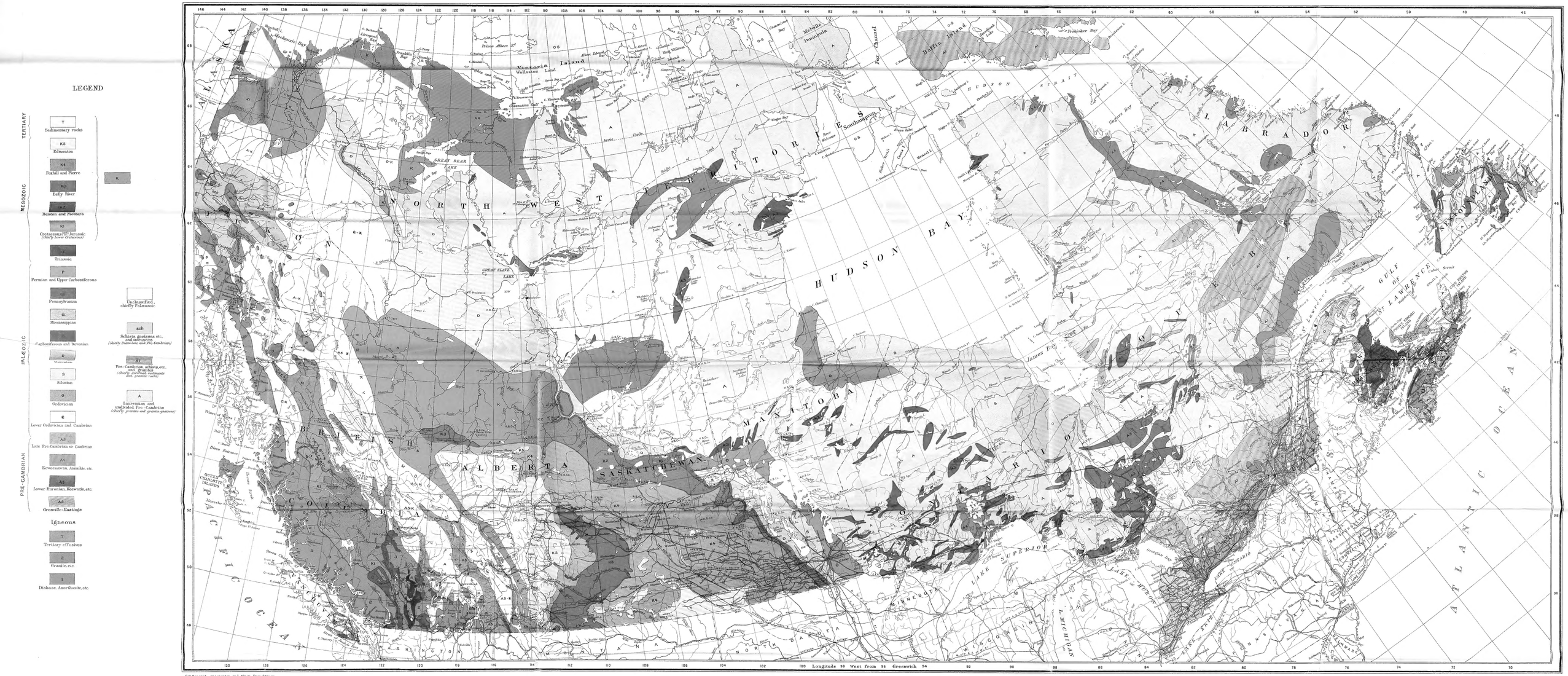
Arisaig

Miles 0 1 2

Kilometres 0 1 2 3

Canada
Department of Mines
GEOLOGICAL SURVEY

HON. L. CODERRE, MINISTER, A. P. LOW, DEPUTY MINISTER
R. W. BROCK, DIRECTOR.



C. O. Senécal, Geographer and Chief Draughtsman.

MAP 91A
(Issued 1913)

Geological Map of the DOMINION OF CANADA AND NEWFOUNDLAND

Scale, 1/6,350,000

Geographical base from engraved plates of the Department of the Interior
Geology of Newfoundland from official map of the colony
Geology compiled by G. A. Young